DOCUMENT RESUME

ED 030 838 AC 004 965

By-Rittenhouse, Carl H.
The Transferability and Retraining of Defense Engineers.
Stanford Research Inst., Menlo Park, Calif.
Pub Date Nov 67
Note-134p.
Available from-Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1968-0-305-215 (96), $.65)
EDRS Price MF-$0.75 HC Not Available from EDRS.
Descriptors-Administrative Personnel, Age Differences, Attitudes, *Career Change, Employment Opportunities, Employment Qualifications, *Engineers, Family Status, Income, *Industry, Investigations, Marital Status, *National Defense, Transfer of Training, *Vocational Retraining

This study was undertaken to describe any special barriers to the transfer of engineers from defense to commercial work, and to evaluate retraining and reorientation techniques that might help ease the transfer. Interviews and questionnaires were used to obtain data from about 2,100 engineers and 100 managers in 14 industries. Characteristics, experiences, and attitudes of engineers who had transferred from defense to commercial work in recent years were stressed. These were among the major findings; (1) no important barriers to transfer were detected relating to age, marital status, or family status; (2) engineers saw managers' attitudes, greater commercial cost consciousness, and differing specialty and manpower requirements as possible barriers to transfer; (3) motivational and attitudinal factors tend to support rather than oppose transfer to commercial industry; (4) on the job training and other inhouse programs were favored as means of retaining; (5) managers were more optimistic about transferability of skills and attitudes than about availability of openings; (6) defense engineers entering commercial industry would probably be best suited to research and development, new design, advanced engineering, and analytical areas. (ly)

ED030838

ACDA/E-110

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

THE TRANSFERABILITY
AND RETRAINING OF DEFENSE ENGINEERS

PREPARED FOR

The U.S. Arms Control and Disarmament Agency

PREPARED BY

Carl H. Rittenhouse
Stanford Research Institute

AC 004 965

ACDA/E-110

The conclusions and recommendations in this report are those of the contractor and do not necessarily reflect the views of the United States Arms Control and Disarmament Agency or any other agency of the United States Government.

ACDA/E-110

FOREWORD

This is the latest in a series of research studies exploring the domestic economic implications of reductions in defense demand.

The United States Arms Control and Disarmament Agency (ACDA) is charged, as one of its responsibilities, with pursuing appropriate research to assess "the economic...consequences of arms control and disarmament, including the problems of readjustment arising in industry and the reallocation of national resources" (P.L. - 87-297).

In May 1966, Stanford Research Institute, Menlo Park, California, was competitively selected by ACDA to perform a research study on "The Transferability and Retraining of Defense Engineers."

The objectives of the study were:

(1) To identify and describe any special barriers to the transfer of engineers from defense to commercial work;

(2) To identify and evaluate retraining and reorientation techniques that will aid in easing the transfer.

This publication represents the complete study which was submitted to ACDA in November 1967.

The principal author of the report was Dr. Carl H. Rittenhouse of Stanford Research Institute (SRI). Dr. Howard Vollmer of SRI and Professor Albert Shapero of the University of Texas also made significant contributions.

William C. Foster
Director

ACKNOWLEDGMENTS

This study could not have been completed without the help and cooperation of a great many people, to whom we want to express our most sincere thanks.

We are grateful to the United States Arms Control and Disarmament Agency for the necessary financial support, for stating and setting the framework of the research problem in clear and concise form, and for providing continuing guidance and insight during the course of the study. In particular, the contributions of Geoffrey Faux and John Cambern as Project Officers were substantial and very much appreciated.

Executives and managers in the cooperating companies gave generously of their time in making administrative arrangements and in allowing the project staff to interview them in depth. The responses of individual engineers in filling out and returning the data collection instruments were most gratifying, both in respect to numbers and serious attention given to the task. We are deeply indebted for their help.

Project consultants included Albert Shapero, professor of management at University of Texas, William Pedersen, director of personnel at Stanford Linear Accelerator Center, and Murray Weidenbaum, professor of economics at University of Washington.

Stanford Research Institute participants in the project were:

Carl H. Rittenhouse, Project leader
John J. Bosley
Robert C. Heald
Richard P. Howell
Terence G. Jackson
John J. McAuliffe
Wesley L. Tennant
Howard M. Vollmer

CONTENTS

FOREWORD iii

ACKNOWLEDGMENTS v

I INTRODUCTION 1

Method of Approach 2
Definitions of "Defense," "Commercial," and "All Other" work 5

II SUMMARY AND CONCLUSIONS 6

Barriers and Aids to Transfer as Seen by Engineers 6
Managers' Opinions and Perceptions 7
Retraining 8
Comparison of Defense and Commercial Environments and Engineers 9

III BACKGROUND AND HYPOTHESES 10

Review of Past Research 10
Differences in Defense and Commercial Environments Suggested by Previous Analysis 13
Economic Aspects 19
Hypotheses Relating to Barriers to Transfer 20

IV METHOD OF APPROACH 24

Development of Companies Sample 24
Development of Engineers Sample 26
Development of Managers Sample 28
Development of Questionnaires and Interview Guides 28
Administration of Questionnaires and Conduct of Interviews . 30
Data Collection, Processing and Analyses 31

V BARRIERS AND AIDS TO TRANSFER 33

Engineers' Data, Opinions and Perceptions 33
Managers' Opinions and Perceptions 40

CONTENTS

VI DEFENSE ENGINEERS COMPARED WITH COMMERCIAL ENGINEERS 47

Engineering Field 47
Work Functions 47
Supervisory Factors 48
Organizational Identification 49
Professional Identification 49
Years of Experience 49
Age 49
Marital Status and Dependents 50
Salaries 50
Education 50
Employer Courses 51
Summary 51

VII RETRAINING AND REORIENTATION FOR TRANSFER 53

VIII DISCUSSION OF FINDINGS 55

The Disarmament Situation 55
Significant Barriers and Aids to Transfer 55
Significant Training and Reorientation Preparations 58

APPENDIXES

A QUESTIONNAIRE AND INTERVIEW GUIDE 61

B SUPPORTING DATA 80

C THE VALIDITY OF THE GENERAL CONCLUSIONS 109

CITED REFERENCES 121

BIBLIOGRAPHY 123

TABLES

1 Highest Degree by Type of Present Employment 81

2 Specialty in Which Now Working by Type of Present Employment 82

3 Existence of Different Specialties in Commercial Work as a Transfer Problem by Type of Present Employment 83

4 Need for More Generalists in Commercial Work as a Transfer Problem by Type of Present Employment 84

5 Courses Needed to Transfer from Defense to Commercial by Type of Present Employment 85

6 Work Function in Which Now Engaged by Type of Present Employment 86

7 Ease of Defense - Commercial Transfers Compared to Other Transfers by Type of Present Employment 87

8 More Consideration of Cost Factors in Commercial Work as a Transfer Problem by Type of Present Employment 88

9 Less Emphasis on Reliability in Commercial Work as a Transfer Problem by Type of Present Employment 89

10 Interest and Challenge of Defense or Commercial Work as a Transfer Problem by Type of Present Employment 90

11 Hoped-for Employing Organization and Type of Work in Ten Years by Type of Present Employment 91

12 Hoped-for Specialty and Supervisory Role in Ten Years by Type of Present Employment 92

13 Assumed Managers Attitudes Toward Defense Engineers as a Transfer Problem by Type of Present Employment 93

14 Engineers Estimates of Most Serious Transferability Problem by Type of Present Employment 94

15 Specialty in Last Previous Defense Employment by Type of Present Employment 95

16 Function in Last Previous Defense Employment by Type of Present Employment 96

17 Level of Present Supervisory Activity by Type of Present Employment 97

TABLES

18 Supervisory Responsibility in Defense Work Before Present Job by Type of Present Employment 98

19 Supervision in Immediate Work Group by Type of Present Employment 99

20 Supervision by Last Previous Defense Manager by Type of Present Employment 100

21 Supervision by Last Previous Commercial Manager by Type of Present Employment 101

22 Identification with Present Organization or Engineering Profession by Type of Present Employment 102

23 Age by Type of Present Employment 103

24 Gross Annual Salary by Type of Present Employment 104

25 Specialty Field of Highest Degree by Type of Present Employment 105

26 School from Which Highest Degree Received by Type of Present Employment 106

27 Present Employer Courses by Type of Present Employment . . . 107

28 Past Employer Courses by Type of Present Employment 108

I INTRODUCTION

Purpose and Objectives

One of the responsibilities of the U.S. Arms Control and Disarmament Agency is that of planning for the domestic economic consequences of any arms control or disarmament activities that may be undertaken as a result of the negotiation of international agreements. One part of this responsibility is the development of information and techniques for meeting the problems of reallocation of national resources and the resulting readjustment in industry. A primary factor in such reallocation is in the nation's technical-professional workforce. Planning to make the force transferable is important for national economic stability, for the mitigation of major deleterious effects to the individuals involved, and for obtaining maximum usefulness of this valuable resource for furtherance of national goals.

The subjects of earlier related studies sponsored by the Agency included the effects of reduced defense demand on the electronics industry, defense industry diversification, the conversion potential of the shipbuilding industry, and the layoff and re-employment experiences of aircraft workers at the Boeing, Republic, and Martin companies. In addition, a study of the transferability of blue collar workers is in its final stages.

The nation's technical-professional workforce is a valuable but relatively inelastic resource. At present, defense activities employ the largest single fraction of this resource. Therefore, the ability to expedite the transfer of engineering manpower from defense technology and industry to commercial technology and industry, in the event of declines in funding resulting from arms control or disarmament agreements, is of primary national importance.

The purpose of the study here reported is the investigation of the transferability of one type of technical personnel--engineers. These are individuals classified by themselves and by their companies as engineers. No engineering aides, draftsmen, or other peripheral personnel are included in the study, nor are scientists unless they are currently employed in engineering categories. The aims of the research are to determine those most critical barriers that may deter the transfer of defense engineers to commercial jobs, and the role that retraining and reorientation might play in overcoming such barriers.

Planning for transfer of engineers can be based on the assumption that, while cutbacks in defense funding and employment might be substantial, they would almost certainly be carried out over a considerable period of time. Given this assumption, however, it should still be anticipated that readjustments for several industries, for many individual companies, and for thousands of individual engineers would be major problems, the solution of which may require government assistance.

The problem of readjustment would be most acute in certain industries--notably aircraft, electronics, communications equipment, and ordnance--since such a large share of the sales of these industries are to the defense sector of the government. There is, in addition, geographic clustering of these industries that would tend to compound the adjustment difficulties in certain areas and require the movement of some engineers to other areas. Because of the high proportion of resourses devoted to research and development (R&D) in defense industry, engineers and scientists are used much more extensively there than in most commercial industry. The very high technological capability of most large defense companies has not, so far, been converted to commercial uses to any significant extent, even in those companies that have made substantial efforts to diversify in anticipation of changes in defense funding.

In view of considerations such as those above, it appears probable that the transfer of engineering manpower may be difficult and that information relative to the problem as it concerns the skills and attitudes of individual engineers and managers is necessary for federal government policy making and planning.

The objectives of the present study were:

1. To identify and describe any special barriers to the transfer of engineers from defense to commercial work.
2. To identify and evaluate retraining and reorientation techniques that will aid in easing the transfer.

Method of Approach

To fulfill the objectives of the study, information was obtained from approximately 2,100 engineers and 100 managers in 14 industrial companies throughout the United States by means of interviews and questionnaires. The characteristics, experiences, and attitudes of engineers who had actually transferred from defense to commercial work in recent years were of particular interest. The sample, it is believed, represents a sufficient variety of specialties, technologies, company sizes and types, and geographic locations to provide a broad range of experience for identifying transfer problems and solutions.

The Sample of Companies

The 14 companies in which the engineers and managers worked were chosen on the following criteria:

1. Companies for which there was evidence or a high probability that engineers had transferred or would in the future transfer from defense to commercial work within the company or to its commercial divisions from other defense companies.

2. Companies representing broadly differing technologies and engineering specialties, since transfer experiences might differ both in severity and kind with the different skills.

3. Companies varying in proportions of defense and commercial work and in size, since these factors were felt to bear on transfer experience.

4. Companies in industries, such as electronics and aircraft, in which transfer problems were expected to be especially acute because of their high proportion of defense-financed activity and large number of engineers.

5. Companies located in different geographical areas in the United States.

The Sample of Engineers

The 2,100 engineers who returned questionnaires were categorized in the following seven groups and their responses were compared. There were three groups now in commercial work:

1. Those who had transferred from defense work in the same company

2. Those who had transferred from defense work in a different company.

3. Those who had had no previous defense experience

There were also three groups now in defense work:

4. Those who had transferred from commercial work in the same company

5. Those who had transferred from commercial work in a different company

6. Those who had had no previous commercial experience

Finally there were:

7. Those now in nondefense government work

Twenty-four percent of the total group had made the defense-to-commercial transfer and 33 percent had made the commercial-to-defense transfer, for a total of 57 percent who had both defense and commercial experience.

Specific engineering functions and specialities were defined in the sample to obtain a distribution as representative as possible of the distribution of specialties in defense-related industries as a whole.

The Sample of Managers

More than 100 line, personnel, and training managers were interviewed in depth to obtain their opinions and evaluations regarding transfer problems and solutions. Ninety percent were line managers and, of these, some 80 percent had managed both defense and commercial activities at some point in their careers. Over 60 of the managers completed the questionnaire but these data are not included in the data from engineers' questionnaire. University and other personnel concerned with engineering training were also interviewed.

Questionnaire and Interview Guide

The questionnaire was-self administered. It contained items on potential barriers to transfer, assessment of their seriousness, and facilitating factors such as retraining and reorientation. The items were categorized under (1) present work activities and attitudes, (2) past work activities and attitudes, (3) background and educational experience, and (4) specific opinions relating to transfer problems.

The interview guides provided for obtaining information on managers' assessment of the seriousness and extent of problems connected with transfer, assessment of the role of training in overcoming these problems, experiences in their companies with transfer, assessment of the role of attitudes in transferability, and other relevant points suggested by those interviewed.

The use of both questionnaires and interviews provided both extensive and intensive coverage of matters central to the concern of the study. A copy of the questionnaire and interview guide appears in Appendix A.

Definitions of "Defense," "Commercial," and "All Other" Work

The following definitions were used in the study:

1. "Defense work" is work primarily related to end products contracted for and sold to the U.S. Army, Navy, Air Force, or the military services of allied countries (whether under prime contracts or subcontracts).

2. "Commercial work" is work primarily related to end products for sale to consumers (individuals or companies) in the private sector of the economy. It should be noted that commercial work is varied and that some sectors of it, particularly those having to do with the development and production of capital goods, resemble defense work. This distinction is discussed in detail later.

3. "All other work" includes nondefense work for other federal agencies such as NASA or the AEC, work for regional, state, or local government agencies, and any other work not covered by the two terms above. (Transferability for this category was not directly considered in the study, but it was necessary to define it in order to place the individual engineers who participated in the study in the correct categories).

II SUMMARY AND CONCLUSIONS

The focus of the study was on (1) transfer barriers in the area of skills and attitudes and (2) training and reorientation techniques that might be effective in facilitating removal of such barriers.

Barriers and Aids to Transfer as Seen by Engineers

1. A presumed lack of cost-consciousness among defense engineers is regarded as a deterrent to transfer by four out of five engineers in the total sample.

2. More than two-thirds of the engineers perceive as a transfer problem the attitude of commercial managers that defense engineers are not well suited to commercial work.

3. More than half the sample of engineers said that they felt different specialty requirements in the defense and commercial fields might be a transfer problem.

4. More than half the sample felt that a requirement for more generalists in commercial industry might be a problem.

5. Of all transfer groups (those who have had both defense and commercial experience), 40 percent felt that transfer would require no additional training or only on-the-job training. The corresponding percentage for nontransfer groups was approximately 30 percent. Those who expressed a need for courses specified cost accounting, cost analysis, economics, and manufacturing, production and industrial engineering as appropriate areas. The lack of such courses does not, however, seem to constitute any barrier to transfer, since the proportion of both defense and commercial engineers who have had these courses is about the same.

6. Among those engineers who had experienced transfers, more than three out of five felt that defense-to-commercial transfers were about equal in difficulty to other kinds of transfers they had made.

7. Among engineers who had actually made the transfer from defense to commercial sectors, only about 6 percent felt that it was not very easy or was very difficult. Among those who had not made

the transfer, about 20 percent felt that it would not be very easy or that it would be practically impossible.

8. There is a willingness to undertake commercial or nondefense government work as a future career even among those now employed in defense who are satisfied with their present work. Those now in commercial work generally would prefer to remain in it. Motivational and attitudinal factors appear, therefore, to support rather than to oppose transfer.

9. No important barriers to transfer were detected in the study relating to the engineers' age, marital status, or number of dependents.

Managers' Opinions and Perceptions

Primary points regarding transferability made by defense and commercial managers were as follows:

1. Managers were generally optimistic about transferability from the point of view of skills and attitudes. They were less optimistic about the ability of commercial industry to absorb large numbers of defense engineers.

2. Managers feel that commercial engineers must be more cost-conscious than defense engineers, but many pointed out that the commercial and defense sectors are no longer as different with respect both to cost-consciousness and product reliability as was once the case.

3. Technical skill levels are regarded as higher in defense industry than in commercial industry. In the opinion of some managers, this should not be regarded as a deterrent and may be a positive advantage for commercial industry in upgrading its effectiveness.

4. Commercial engineers are product-oriented, while defense engineers tend to specialize in more narrow technical fields and do not follow a product through from start to finish. This difference might require some reorientation on the part of transferred defense engineers, but the problem is not thought to be excessively serious.

5. With regard to work functions, defense engineers would probably be best suited to R&D, new design, advanced engineering, and analytical areas.

6. There are substantially greater proportions of defense engineers engaged in documentation activities than is the case with commercial engineers. Such defense engineers do not perform conventional engineering functions; they write specifications, handbooks, and manuals. They work in planning and in program and configuration management, as well as quality assurance and reliability engineering. Most are trained as engineers. Commercial industry in general does not feel the need for such large numbers of these individuals and could not afford them if it did. Thus, they may meet serious transfer problems, and the retraining requirements for them should be identified.

7. One other group--aeronautical engineers, 60 percent (40,000) of whom are in defense industry--may also have transfer problems since the demand for engineers in both commercial and military aircraft production may level off or decline in the future. If, as seems likely, the civil space program cannot absorb large numbers of aeronautical engineers, retraining and reorientation may be required to fit them for jobs in other specialty fields. The nature and extent of the requirement should be determined.

8. Commercial industry may not have any less interest and challenge than does defense industry but it is of a different kind, focusing on manufacturing feasibility and the balancing of cost and performance considerations, while in defense greater emphasis is given to pushing technical limits to achieve maximum performance.

9. In a general sense, commercial engineers need to be more concerned with marketing considerations than do defense engineers. This is primarily a matter of the orientation toward specific products required for commercial work and is related to the cost considerations mentioned above.

10. Individuals are transferable, particularly if they can be brought gradually into a functioning commercial unit so that they can learn on the job by absorption. Organizations are not transferable.

Retraining

Both engineers and managers agree that where retraining is required, it should be done through in-house programs, especially on-the-job training. Formal courses are regarded as not necessary. Absorption into a commercial program over a period of time and the learning of new skills through direct contact with engineers already in the organization is the preferred method, since it permits the engineer to produce while learning. This is also the most effective way of promoting changes in attitudes with respect to cost-consciousness, reliability, product orientation, marketing, and the like.

If large scale changes in skill specialties are required, formal training might be more in order but some means of financing it would have to be found. Government assistance through tax write-offs or some such mechanism might be considered.

Comparison of Defense and Commercial Environments and Engineers

1. There is a larger proportion of mechanical engineers in the commercial engineering workforce than in the defense engineering workforce. The opposite is true of electronics engineers. It may be easier for mechanical engineers to transfer from defense to commercial industry, and more difficult for electronics engineers to do so because of differences in demand for the two specialties in commercial industry. There are also training implications in this finding.

2. Systems analysis and design are engaged in by a larger proportion of defense engineers than of commercial engineers. The opposite is the case with respect to component and hardware product design. This imbalance has both transfer and training significance.

3. Defense engineers may function at a somewhat higher technical level on the average than do commercial engineers. The proportion of those with advanced degrees exceeds the proportion in commercial industry. It cannot be clearly shown that a higher educational level signifies greater specialization but, if it does and if overspecialization among defense engineers is a transfer problem as some of the other study data suggest, this might be a barrier to transfer.

III BACKGROUND AND HYPOTHESES

Review of Past Research

A review was made of literature drawn from a variety of sources that might be considered to have a bearing on the problem of transferability of engineers in general, and from defense to commercial work in particular. The literature reviewed included:

1. Literature on manpower planning and manpower policy
2. Reports on the demand for engineers that were prepared by professional societies for engineers and the government
3. Papers on utilization of scientists and engineering
4. Literature on theories of vocational choice that is appearing in the fields of industrial psychology and labor economics
5. A series of reports on the structure and dynamics of the defense R&D industry prepared by SRI for the Department of Defense and the Aerospace Industries Association
6. Reports prepared for the United States Arms Control and Disarmament Agency directly concerned with defense cutbacks in Seattle, Denver, and Long Island, and consequent problems of re-employment of the work force.
7. A doctoral thesis dealing with defense cutbacks in Massachusetts.

This review clearly points to the fact that little is known in a systematic way about transferability, particularly transferability of engineers from defense to commercial work. The empirical studies proved to be the only literature that might be relevant to this study. Despite the limitations of our present body of information however, a few generalizations can be supported on the basis of the literature. Barriers to transfer of engineers can be categorized as (1) structural barriers, (2)barriers due to marginality, (3) barriers due to the perception of managers, and (4) barriers due to the mismatch of specific skills. Each of these categories suggests a different kind and magnitude of retraining.

In all the literature that was reviewed, the primary and obvious problem identified was the lack of available work, a structural problem.

In all of the case studies of defense cutbacks, the concerned employees who were questioned invariably pointed out that the major problem of re-employment was the lack of available jobs that met their training and experience. In the Denver study[1]* 56 percent of the 592 professionals who answered the questionnaire pointed to this as a major difficulty in obtaining work. In a similar study in Seattle[2] the largest problem in obtaining employment was the lack of jobs available in the same job category held by the men who were laid off. Engineering employment in the defense sector is far higher than that found in the nondefense sector relative to total employment and sales in each sector. Therefore, in any terms, a large laying off of defense engineers must result in a substantial proportion of them being unable to find any kind of engineering opening, let alone the kind that matches their qualifications. In the case studies it was pointed out that, where openings were available in specialties similar to those found in defense, the displaced engineers were able to obtain employment in a short time at salaries equal to or better than they had received previously.

These findings suggest that retraining in response to this particular aspect of the problem could mean training for a profession or occupation other than engineering.

A second major problem in transferability is that faced by the defense engineer who, in terms of age and level of education, may be considered "marginal." This poses a transferability problem of major proportions that is discussed prominently in almost every segment of the literature reviewed. In all of the case studies of defense cutbacks, it was repeatedly underlined that older workers (variously identified as "above 49" or "over 55") had the greatest difficulty in finding new employment. In the Massachusetts study[3] age was found to be the most serious problem affecting re-employment of engineers. In the Denver study[1] 26 percent of the questionnaire respondents in the professional category identified age as a primary difficulty. In the Seattle study[2] it was pointed out that older workers found re-employment more difficult than did others. In the SRI studies[4,5] data on the age composition of the aerospace workforce pointed to a process in the defense industry that has resulted in a severe and continual displacement of older engineers from the workforce.

Similarly, the engineers without university degrees (who are also found to be older than the average) encountered the same marginality problem. They found the lack of a degree to be a substantial barrier to re-employment. This was repeatedly underlined in the case studies[1,2,3] by the length of time that such engineers remained unemployed and by the number of questionnaire respondents that identified this as a problem. In the SRI studies[4,5] the data showed a linear decrease with time in the number of engineers without degrees hired by aerospace companies over the last 30 years. For the older engineer, retraining in engineering apparently makes no difference; for the engineer without a degree, retraining is a matter of "certification." Thus, training to obtain the degree rather than specific content of the training may be the primary factor.

---

* See Cited References near the end of this report for full titles of the studies mentioned.

Throughout the literature a major barrier to transferability is found to be the way the nondefense manager perceives defense work and defense engineers. In the Denver study[1] "Reluctance to employ defense workers" was listed by 37 percent of the responding professionals as a major difficulty in obtaining employment following a cutback. In the Long Island study[6] a large number of the employees mentioned the reluctance of firms to hire former Republic Aviation employees because of a generalized ill will toward defense workers, and the possibility that they would return to defense work as soon as it became available. In one of the SRI studies[7] Weidenbaum quotes top executives of companies that did both defense and nondefense work, to the effect that these executives felt that defense workers were not adequately oriented toward commercial work and even that they were different kinds of people. This information suggests that there might be a retraining problem addressed to reorienting nondefense managers. In contradistinction to these perceptions, Mooney[3] points out that the notion that engineers employed in defense suffer from a "trained incapacity" to perform commercial work is somewhat of a myth. Twenty-three percent of the engineers who were re-employed in his study of displaced defense engineers in Massachusetts had obtained work in consumer product or other commercial fields. He points out that the lack was in the number of engineering job openings, not in the specific capabilities of the displaced engineers.

The literature that was reviewed provides little evidence to support the contention that there is a major barrier to transferability in the mismatch of the particular skills and experiences found in defense engineers with those required by commercial enterprises. In all of the case studies it was apparent that whenever and wherever a similar kind of work to that done by the defense engineer was available in the commercial sector, he made the transfer without difficulty. This casts serious doubt on the notion defense work has a serious "warping" effect. There is also much implicit support for the idea that defense engineers are highly transferable technically in the SRI studies of the defense R&D industry.[4,5] Eli

Ginzberg in his book, The Development of Human Resources[8] indicates that engineers, more than others, have been noted for "transferability." He points out that, unlike most professions, engineers specialize early and then branch out into other fields later in their careers.

Some of the literature discusses the question of salary differentials as a barrier to transfer. In the case studies many engineers expressed reluctance to take lower salaries, but the operational evidence on re-employment makes it clear that, under conditions of major layoff, engineers accept lower salaries and are consequently employed by nondefense companies.

In summary, the available literature suggests that, in terms of specific courses in engineering or in business administration and the like, retraining can play little part in effecting a marked increase in the transferability of engineers from defense to commercial work. Retraining, if it is to play a role at all, will have to be of a magnitude that takes the engineer out of engineering, provides new kinds of occupational support for the older worker, or provides a degree for the engineer without one. There is evidence to support the idea that some reorientation for nondefense managers is important and that perhaps retraining courses for defense engineers would provide the apparent skills to overcome the prejudices of commercial managers.

Differences in Defense and Commercial Environments Suggested by Previous Analyses

Defense engineering and its management are conditioned by certain pressures that are reflected in the way defense business is conducted and differentiate it from nondefense work. First there is the constant pressure of urgency. Since World War II, defense, or national security, has been assigned the highest priorities in the allocation of our national resources. To meet our perceived needs in defense and to provide us with potential military advantage, we have unstintingly poured money and men into the development of aircraft, missiles, electronics, and atomics. Every effort has been focused on achieving these developments in the least possible time.

While the pressures of urgency have been constantly pushing defense engineering and management, the public nature of the business has provided constraints. Business transactions, in defense, are conducted under public scrutiny. There are the formal reviews of defense awards and of the conduct of defense R&D, the auditing efforts of the appropriate administrative agencies, the overall review of programs, budgets, performance, funds, and policies carried out by Congress, and the independent public scrutiny of government business by a free press.

The pressure to develop and deliver advanced technical devices that have never been built before, while meeting the legal administrative and public demands placed on all government business, has resulted in many differences in environment between defense and nondefense sectors as well as many differences in perception of these two sectors of work in the United States.

Many of these differences, both in kind and degree, may have a critical bearing on the question of transferability and may be keys to determining whether or what kind of retraining might be necessary. It is these differences in technology, market structure, and modes of management that result in variations in work experience and viewpoint which in turn may determine whether or not an engineer from one sector will be able to find employment in the other sector.

Before discussing the relevant differences between these two worlds of work, it is important to emphasize that neither the defense sector nor the commercial sector is monolithic. There are many overlaps between the two sectors as well as great variety and differences within each. It should therefore be clear that the differences discussed in the following sections are modal differences for the most part. Thus, the defense sector, in general, has a much higher fraction of its efforts committed to R&D than does the commercial sector; but in the particular case of the commercial pharmaceutical industry, the investment in R&D is one of the highest relative to other US industries--in this respect it is therefore similar to a large segment of industry in the defense sector. Similarly, the defense sector is generally characterized by very small production runs; however, the small arms defense industry is similar to a large part of the commercial sector in its concern with mass production.

One distinction in particular in commercial industry may be of particular significance for transferability. This is the distinction between the production of consumer goods and the production of capital or producer goods. Since producer goods are often more complex, more reliable, and achieve higher performance levels than consumer goods, they more nearly resemble the type of product turned out in defense industries, and it might be anticipated that transfer from defense to commercial capital goods industries would be easier than transfer to consumer goods industries. In addition, marketing conditions are more similar in defense and capital goods industries, in that both have sophisticated customers who are able to specify precisely what they need and want, and are willing to pay for high quality.

Relevant differences in technology between defense and nondefense include differences in the mix of technologies employed, in the extent to which technology is employed, and in the rate of technical change that is typically experienced. The defense sector is heavily concentrated technologically. The majority of defense dollars are spent on R&D, procurement, and operation of systems identified as aircraft and missiles, electronics, and electronic specialties such as detection and communication. The technologies that predominate are aeronautic and electronic. These technologies have accounted for approximately three-fourths of all the dollars awarded by the Department of Defense for Research, Development, Test and Evaluation (RDTE). Consequently, it is not surprising to find that engineers in the defense sector are also heavily concentrated in terms of technical specialties, with more than half of them having received degrees in aeronautical, electrical, or electronics engineering[5].

The defense sector is also differentiated from the nondefense sector by a much larger involvement in technology, and, particularly, advanced technology. One measure of this difference is obtained by comparing the ratio of R&D expenditure to total sales in the aircraft and missile industry with that for all U.S. manufacturing industries. In the aircraft and missile industry, which is substantially devoted to defense work, the ratio is 28 percent, compared with 4.3 percent[9] for all U.S. manufacturing industries.

The rate of technical change in the defense sector is faster than in the nondefense sector. Since the experience of the atom bomb, the military must support new technology and explore, if only to negate, any possible technical advantage that might be obtained through R&D. Consequently, since World War II, the Department of Defense is the largest single supporter of research and technology in the United States. In the past decade and a half, the defense sector has been marked by every increasing integrations of technology into larger and larger systems, major substitutions of one technology for another in the performance of given functions (e.g., substitutions of missiles and rockets for conventional armaments, nuclear for conventional explosives), substitutions of new for conventional materials, and trends to dimensional extremes (e.g., micro and molecular componentry and circuitry).

The differences in technology between the defense sector and the nondefense sector result in environmental differences that include:

- The larger number of engineers in defense means a larger number of engineers who reach managerial rank of one kind or another
- Different concentrations of specialties in engineering reflecting somewhat different educational experiences, different terminology, and what is in effect a different engineering subculture
- Differences in the sheer number of engineers within defense and nondefense establishments, with a consequent different degree of requirement for accommodation to nonengineering points of view
- The heavy R&D orientation of defense creates a considerable difference in the value placed on advanced degrees and on science backgrounds
- A considerable pressure on defense engineers to accommodate to new technology means that many tend to be working closer to the frontiers of engineering knowledge, to be challenged by this, and to have the use of the most sophisticated available equipment and facilities
- Less concern on the part of defense engineers with manufacturing feasibility since they can, by and large, assume that anything that is designed can be manufactured, given sufficient effort and both substantial and often flexible budgets.

Distinguishing factors in the market structure for defense industries include legal-administrative pressures to maintain competition, the use of contract mechanisms in the absence of a freely competitive market, and the requirement for extensive justifications of contract awards. The defense market is constrained by various legal requirements designed to make sure that defense work is "fairly" awarded and that all organizations with apparent capabilities for the work have an opportunity to bid for it. As a consequence, no company can reach a point where it is assured a share of the market by virtue of its past performance, size, or endurance. This results in a continuous effort to bolster the kinds of resources, including engineering skills, that can be described in brochures and proposals to the government buyer legally responsible for awarding the contract. This has also resulted in managerial practices that have fostered the accusation of "stockpiling of engineers," "pirating of engineers," and "ineffective utilization of engineers and scientists," since it has been necessary for defense companies to collect and hold the apparent technical capabilities that would give them a competitive advantage in bidding.

Because the defense sector is dealing with public goods and services that are vital to the country's welfare, the government is usually in a position where it cannot use the ordinary market mechanism of cancellation of contract. Therefore, in the defense sector, the buyer attempts to use contractual arrangements as a way of requiring management practices that appear to be favorable to successful performance. Since World War II, we have witnessed an enlargement of the contract to include such items as statistical quality control, human engineering, and value engineering. At the same time, the legal nature of the contract relationship may influence technical decisions strongly.

The large amounts of resources allocated to defense have generated a Congressional interest that is proportionate. Consequently, the defense engineering process requires, at every point, analytical support and documentation from highly qualified technical professionals. Contract awards are made on the basis of the technical and management proposals that are submitted as well as the past record of the bidders, and the contract spells out requirements for technical reports, test data, test interpretations, and the like.

The environmental differences resulting from these elements in the market structure of the defense sector include:

- The emphasis on documentation has created a body of engineers who spend all their time in analytical and justification studies. In a study that was done for the Aerospace Industries Association by SRI[10] it was found that the largest single and growing segment of that industry's manpower was concerned with documentation and analysis. In the same study an analysis of the functions performed by the thousands of engineers of a missile company showed that over 20 percent of them were doing analytical studies.

- The generation of new engineering specialties to meet the contractual requirements, many of the specialties being encompassed--or unnecessary--in traditional functions in nondefense industries. These include such specialties as value engineering which is usually subsumed within production engineering in commercial companies, and human engineering which is seldom separated from the regular product design function in nondefense companies.

> A constant pressure to "upgrade" the apparent capabilities of a company in order to look better in proposals, resulting in an emphasis on advanced degrees, the employment of scientists, and the maintenance of many kinds of supporting and "glamorous" technical capabilities as visible signs of capability.

The differences in management that mark the defense sector are a product of the differences in technology and market structure described above, and of the production quantities and processes that characterize the defense sector. It has a project orientation rather than a standard-product orientation and is characterized by small quantities rather than continuous flow mass production. It should be noted again, of course, that there are variations within both defense and commercial sectors, and that commercial capital goods production resembles defense production in many respects. Many defense enterprises build up rapidly to a large operation for a short number of years and then are cut back drastically. For example, on the Titan II program, the number of engineers employed went from less than 50 to just about 3,600 in the transition from conceptual development to the full design and development effort[11]. The effect of such peaking of demand is to create very high mobility among certain engineers, as was indicated in a study showing that one-fourth of the engineers and scientists in the aerospace industry have had more than four jobs[4]. The defense sector also requires the managerial ability to bring together a group of professionals that have never worked together before and get them to produce under a set of conditions that will not continue beyond the project. There is consequently little emphasis on developing a body of skills or an organizational structure for the long run. Appraisal of engineering staff will de-emphasize "company loyalties" and may even place a positive value on the number of relevant projects the engineer has participated in, assessments atypical of the great majority of commercial companies.

Because of the small production quantities that characterize the defense sector, defense managers and engineers need pay little attention to design features that will result in small savings per unit or other goals of mass production. For example, the defense engineer does not place a high premium on design solutions that use progressive dies, but is more prone to design units requiring assembly jigs and fixtures in their production.

The difference in modes of management that mark the defense industry result in environmental differences that include:

> An emphasis on performance over costs (defense engineers may be cost-conscious, but the kinds of costs they are concerned with

are large unit costs rather than small unit costs) which tends to encourage consideration of a variety of radically different technical approaches to product design rather than a consideration of a least-cost product and production tool design.

An overt and documented application of certain formal management techniques such as PERT, which is a means of scheduling and monitoring development, as an end in itself in response to contract requirements.

Levels and kinds of supervision may differ in defense and commercial sectors because of differences in complexity of the work. A systems manager in defense industry might find it difficult to exercise close supervision, even if he wanted to do so, because he could not have all of the detailed and specialized knowledge required. Such supervision might be more easily exercised in commercial industry, which operates at a generally lower technical level. For the individual engineer, this would imply more independence from immediate supervision (with the attendant possibility of greater ultimate accountability) in the defense sector than he may find in a commercial enterprise.

Economic Aspects

This study is focused on individual engineers and the skills and attitudes which would either deter or assist them in making a transfer. Although the economic aspects of the problem are not central to the study, they are fundamental to any rational discussion of engineer transfer. As an instance, there are many more engineers per sales dollar in defense industry than in commercial industry, so that the ability of the latter to absorb any significant number of additional engineers presents a serious problem. This is true quite aside from considerations of skill or attitude transferability. For example, it may be economically very difficult for the commercial sector to take on more than a small proportion of the documentation personnel, mentioned earlier, who constitute a substantial fraction of engineers found in defense industry. The cost of high performance and reliability, to which the talents of many engineers are devoted in defense work, could not be passed on to many commercial customers without a considerable re-education of them and of commercial industry. Relatively less re-education might be required in companies in the producer-capital goods fields, and their quality consciousness might be encouraged if funds now going into defense were diverted to the commercial sector.

Hypotheses Relating to Barriers to Transfer

The preparation of the data collection instruments (a questionnaire and interview guide) required precise statements of the areas to be investigated in the study. Such statements are most readily constructed in the form of hypotheses. Material for the hypotheses was gathered from a variety of sources including the literature reviewed above, interviews, and previous research conducted by SRI and other organizations.

The hypotheses were grouped according to their primary reference. It should be noted, however, that because some of them may appropriately fall in more than one category, the groupings serve only as general guides. The hypotheses were stated as follows:

A. Experience

1. Defense-related experience will be beneficial in transferring to commercial work if:
    a. The commercial work and the defense work make use of similar technologies and require similar technical engineering specialties.
    b. The level of complexity of the commercial work is approximately equal to that performed in the defense sector, e.g., systems engineers in defense could work on commercial systems problems and, similarly, equipment or component engineers.
    c. The development phase or phases in the commercial sector is similar to the project phase in the defense sector, e.g., a design engineer in defense work transfers to design activities in commercial work.
2. Defense-related experience will be a deterrent or barrier to transfer to commercial work if:
    a. The emphasis on high reliability with the accompanying effort to anticipate all problems, typical of defense-related work, is so ingrained in the defense engineer that he finds it difficult to work to the less exacting standards necessary to keep commercial costs down.
    b. The engineer has never done commercial work and his defense work has not required primary consideration of cost-consciousness or orientation to normal commercial marketing practices.

3. The number and variety of previously held jobs (either defense or commercial) will be related to transferability. To the extent that this indicates varied experience and flexibility in adapting to new circumstances, the relationship will be positive.

4. Prior commercial experience will be an aid to transfer since less reorientation to commercial attitudes will be required.

5. Experience as a supervisor or manager will aid transfer to commercial work because of greater attention to costs and marketing considerations.

6. The more time an engineer has spent in defense work, the less transferable he will be.

B. Personal Characteristics including Education, Skills, and Attitudes

1. Deficiencies in technical skill and knowledge will only rarely be a deterrent to transfer, since the general technical level of defense work is higher than or equal to that of most commercial work.

2. If the defense engineer's work has been narrowly specialized in an area of high technology, technical deficiencies might exist for the work to which transfer is being made, but they should be rather easily overcome and of short duration.

3. A high level of technical skill and knowledge may be a barrier to transfer if the work to which the engineer is transferring is at a lower level so that he finds it less interesting or professionally rewarding and his self-image is negatively affected.

4. Successful transfer may be less dependent, in the long run, on specific professional background and experience than it is on such personal characteristics as intelligence, initiative, and independence.

5. The relationship of education to transferability will be complex:

    a. Transfer will be easier for the graduate engineer than for the engineer who has learned all his engineering on the job because the graduate may have a more solid technical base for picking up quickly any special technical skill and knowledge needed for the commercial work. Employer evaluation may be heavily influenced by the presence or absence of the degree, regardless of actual skill level.

b. The reverse may be the case where product design is the function because the man who has learned engineering on the job may be more cost-conscious and less likely to design products that are expensive to produce.

c. It is also possible that the higher the degree attained, the more difficult the transfer will be both because of the higher probability of specialization in a narrow, rarely applicable field and because the Ph.D. engineer might be less interested in commercial work of a lower technical level and less inclined to see himself designing or producing just-good-enough products at competitive cost, and not using his high level skills.

6. Engineers with experience in advanced R&D will have difficulty in transferring because of the gap between this engineering and commercial application, unless commercial industry does more R&D under stimulus of government funds or capital goods demand.

7. Engineers who have had business or management training in addition to engineering will be more easily transferred.

8. The engineer's positive or negative attitudes toward defense and commercial work (his willingness to work in either sector) will be related to transferability.

C. Job Characteristics

1. Lower salaries and less attractive "benefit packages" in the commercial sector will be a deterrent to transfer when, as now, defense jobs are fairly readily available, but they would not be significant barriers in the event of a major defense cutback.

2. Transferability may relate to the function in which the engineer has been engaged. The skills, work backgrounds, and educational attainments of engineers in a given function tend

to differ in kind of quantity from those in others. Engineers in the later production and test phases may have education and skills that are different from those in design functions and, to the extent that requirements for these functions are different between defense and commercial sectors, transfer will be impeded.

3. To the extent that the distribution of engineering specialties may differ in defense and commercial work, a deterrent to the transfer of any substantial number of engineers over a relatively short period of time will exist because of the mismatch between specific skills and knowledge and specific jobs.

4. There is far less emphasis on and far less time and effort applied to the R&D activities in commercial industry and more on sales. Quality control and production engineering may be more stringent in defense work, but the skills are needed in both areas. To the extent that these emphases are different in the two sectors, transfer will be more difficult.

D. Additional Training

1. In-house training programs will be more effective and efficient than programs organized outside the plant, whether these latter are in existing public or private educational institutions or have been specially developed through the cooperation of private industrial firms and public government institutions.

2. Costs and uncertainty about retention of retrained individuals will be significant barriers to the establishment and continuance of retraining programs within companies.

E. Managerial Attitudes

1. Managerial attitudes within commercial industry will be a significant barrier to transfer. Previous studies indicate that many managers feel defense engineers cannot be successfully transferred to commercial work because of their attitudes toward costs and reliability. In a number of instances companies have been hiring commercial engineers while at the same time laying off defense engineers.

IV METHOD OF APPROACH

In order to obtain the data needed to meet the requirements of the study, it was necessary to devise and distribute data collection instruments to a large sample of engineering personnel in industry in the United States. The questionnaire format provides the most expeditious means of obtaining data, and questionnaires can be designed in such a way as to minimize disruption of ongoing industrial activities. It was thought desirable to supplement questionnaire data with information from interviews in considerable depth with managerial personnel known to be experienced and knowledgeable regarding the skills and attitudes of engineers.

Since the focus of the study was on transferability from defense to commercial work, information as to the characteristics, experiences, and attitudes of engineers who had actually made this transfer in recent years was of particular significance. Further emphasis was put on obtaining information from those who had made the transfer within the same company since such transfers could be assumed to be the least disruptive both to the economy in general and to the individual having to change jobs, and would, therefore, be the most desirable kind.

Development of Companies Sample

The basic study requirements as well as those specific to the engineer sample led to the establishment of criteria for the selection of companies and other establishments.

The first criterion was evidence that defense-to-commercial transfers had been made within the company or that the company had received transfers into its commercial divisions from other defense companies. Since it was felt that valuable information about the transfer experience could be obtained from those who had transferred in the other direction, either within companies or between companies, some establishments employing commercial-to-defense engineers were also included in the sample. In some instances, it was possible to get specific information on the number of transfers made in the company. In other cases, there was a reasonable probability that such transfers had been made because of known diversification efforts on the part of the company or data indicating major shifts in the proportions of defense and commercial work in the last few years. Certain companies meeting the latter criteria were, however, eliminated if diversification had taken place by acquisition or merger, for example, and there was therefore less reason to expect transfers within companies; in these cases, positive evidence of transfers was required for inclusion within the sample. Similarly, it was required for companies having both substantial defense and commercial functions kept geographically and administratively separate, so that very little transfer normally takes place.

It was anticipated that transfer problems might differ both in severity and kind relative to various engineering specialties and technologies. The company sample, therefore, included firms in a variety of fields including aircraft, aerospace, electronics, automotive equipment, office equipment, industrial and consumer goods, and others.

Although the study was not primarily concerned with economic barriers to transfer, certain economic factors were considered in making the selection of firms, since it seemed probable that they might relate to the kinds of transfer experiences that individual engineers have had. Transfers might be easier in those companies having a large commercial base into which engineers might move in the event of necessity and in which the numbers of engineers to be moved would be smaller because of relatively low proportions of defense work. Thus, the sample included firms with varying proportions of defense and commercial work: the range was from 5 percent defense to 85 percent defense.

Company size was also a consideration in choosing the firms, since ability to absorb engineers in commercial work might be expected to be related to size. The companies ranged from $55 million to $2 billion in gross annual sales.

The degree and kind of diversification in a given company may also affect transferability and transfer experiences, so consideration was also given to this factor in choosing companies for the study. Diversification in a company relates to the variety of specialties and job functions engineers previously employed in defense may enter, and therefore to training or retraining problems.

Finally the sample of companies reflected industries in which the transfer problem is likely to be the most acute (particularly aircraft and missiles) because of their large numbers of engineers, the high ratio of engineers to sales dollars and of R&D expenditures to sales dollars, and the heavy proportion of defense-financed activity.

The final sample was composed of 14 companies with some 75 divisions or other establishments from which data were drawn. In 1966 the gross defense sales of these companies represented about 13 percent of the total of all defense sales, and they employed an estimated 20,000 engineers. The sample represented a broad spectrum of technologies, defense-commercial ratios, and geographic locations. It is believed to be generally representative of companies within which and between which defense-to-commercial transfers would occur in the event of changes in the defense budget.

Development of Engineers Sample

Since the primary approach of the study was to learn from the actual transfer experiences of those who had moved in the defense-to-commercial direction, a special effort was made to obtain the responses of engineers who had had that experience. However, there was evidence from previous studies that relatively small numbers of such transfers had been made,and that, therefore, in order to provide sufficient numbers for analysis, engineers with other kinds of experiences should also be included in the sample. These included engineers who had transferred from commercial to defense work either within the same company or between companies. Since these groups have had both commercial and defense experiences, their responses were particularly relevant to the transfer problem. Finally, for control and comparison purposes, groups having only commercial experience, those having only defense experience, and those now employed in nondefense government work were included. Completed questionnaires were obtained from approximately 2,100 engineers in the 14 chosen companies, located in the northeastern, midwestern, northwestern, and southwestern regions of the United States. The proportion of each group in the total sample of engineers was as follows:

Those now in commercial work who:

(1) transferred from defense work in the same company--14 percent
(2) transferred from defense work in a different company--10 percent
(3) have had no previous defense experience--10 percent

Those now in defense work who:

(4) transferred from commercial work in the same company--15 percent
(5) transferred from commercial work in a different company--18 percent
(6) have had no previous commercial experience--21 percent

Those now in defense work who: (cont.)

(7) Those now in nondefense government work--13 percent

Thus, 24 percent of the total group had made the defense-to-commercial transfer and 33 percent had made the commercial-to-defense transfer, for a total of 57 percent who have had both defense and commercial engineering experience.

In addition to consideration of transfer experience in sample selection, specific engineering occupations and specialties were defined in an effort to obtain representative groups in these respects. The aim was to produce a sample in which the engineering specialties would reflect as closely as possible the distribution of specialties in defense-related industries as a whole. Data from SRI's studies of R&D industries indicate that four broad categories of engineers--electrical, electronic, mechanical, and aeronautical--include about 80 percent of all engineers employed in primary defense industries. Of the remainder, a substantial number are categorized as general engineers, smaller numbers are civil and industrial and management engineers, and there is a scattering of nuclear, chemical, cryogenic, thermal, ceramic, and other engineers. The proportions in the major categories vary somewhat between the two major defense industry groupings (aircraft and missiles, electronics) with a substantially larger proportion of aeronautical engineers in aircraft and missiles and of electrical and electronic engineers in electronics, as would be expected. In the current study, about 14 percent are aeronautical engineers, 20 percent are mechanical engineers, and 40 percent are electronic or electrical engineers, accounting for about 75 percent of the total sample. This is reasonably close to the proportions found in defense industry as a whole, with a slightly higher proportion of aeronautical engineers and a slightly lower proportion of mechanical engineers in the present sample.

Within each company included in the study, the engineer sample was chosen by company personnel, usually division managers. The only special guideline provided by the researchers was that an effort be made to locate engineers who had made the defense-to-commercial transfer. Locating was done by a variety of means including the examination of personnel records and the use of managers' personal knowledge of their subordinates. With the exception of this attempt to obtain defense-to-commercial transferees, the sample was chosen randomly by taking every nth name on a roster of engineers or some similar procedure. In order to avoid disruption of work activities as much as possible, no company was asked to name more than

25 percent of its engineers for inclusion in the study, although some did distribute questionnaires to as many as 50 percent of their engineers.

It is felt that the final sample is sufficiently varied with respect to specialties, technologies, company size and type, and geographic location to provide a full spectrum of experience, on the basis of which transfer problems and solutions can be identified without serious danger of missing any significant variables. The sample is, therefore, representative in that sense, and probably statistically as well, although the latter point is less clear since it is not possible to define the population with complete precision.

Development of Managers Sample

In order to explore the transfer question in greater depth with experienced individuals, a sample of managerial personnel from each of the companies in the study was chosen for interviewing. Most of these individuals also filled out the engineer questionnaire before the interview, but these data were not included in the results for engineers. The choice of managers to interview was made by the senior manager who had been given the responsibility for assisting the study in each company. The researchers specified that they should be engineering managers at various levels, and that it would be desirable if they had managed both defense and commercial activities at some point in their careers. Approximately 100 such managers were interviewed, some 80 of whom had both defense and commercial experience, usually in managerial functions. The median engineering experience level was at least 20 years. Most were line managers below the level of division manager. About 66 percent had as their specialties, electronic or electrical engineering, aeronautical engineering or mechanical engineering. In addition, staff people in training or personnel functions, some of whom are engineers, were interviewed. University personnel and other specialists in engineering education and manpower were also interviewed.

Development of Questionnaires and Interview Guides

In accordance with the aims of the study, questionnaires were designed to elicit responses having to do with barriers to transfer, assessment of their seriousness, and specification of facilitating factors such as retraining or reorientation. The questionnaire (see Appendix A) contains 56 items and was designed to obtain the greatest possible amount of information in the least amount of time (about 20 minutes). The items in the questionnaire are of three basic types:

1. Those relating primarily to actual or perceived problems associated with the transferability of engineers from defense to commercial work;
2. Those relating to background or experience factors hypothesized to be related to transferability, either positively or negatively; and
3. Those relating to other conditional factors about which information was needed in order to make a meaningful analysis.

On the questionnaire form the items were grouped into four categories having to do with present work activities and attitudes, past work activities and attitudes, background and educational experience, and opinion questions relating to specific kinds of transfer problems.

The questionnaire items were designed also to permit cross-comparisons with information obtained from a variety of other surveys of engineers and scientists and therefore more meaningful interpretations in the larger context.

The purpose of the interviews with managers was to obtain information in depth on:

1. Managers' assessments of the relative seriousness and extent of the problems and barriers to transferability;
2. Their experiences and opinions regarding the role of training in overcoming these problems;
3. The experiences of their companies in retraining activities connected with past transfers of engineers from defense to commercial work, and the degree to which they believe that these experiences are indicative of what would occur in the case of large-scale transfers of engineers necessitated by extensive cutbacks in defense programs;
4. Managers' opinions on the role of attitudes in the transferability of engineers, and the ways in which training activities might be used to modify these attitudes; and
5. Other relevant matters that might be suggested by manager interviewees.

Most of the managers interviewed were also asked to complete the questionnaire given to individual engineers in order to obtain information relative to their work activities and attitudes, their backgrounds and educational experiences, and their opinions regarding problems of transferability in the precategorized "check list" form. However, because of their broader experience of trying to handle transfer problems from a managerial perspective, there was also a need to collect data in a freer, less structured form.

The interview guide (see Appendix A) shows that the interviews started with broad general questions designed to bring out ideas which were salient in the mind of the respondent and then went on to more specific questions relative to the aims of the study that might not come so readily to the consideration of the interviewees.

All of the topics included in the personal interviews--a general evaluation of problems of transferability, a more specific discussion of the role of training (or retraining) in transferability, the experience of companies in this regard, and an analysis of attitude factors in transferability--are central to the primary objectives of the study.

Through the use of both questionnaires and interviews, the study achieved extensive coverage of a broad sample of engineers and engineering managers and intensive coverage of a more limited sample of engineering managers with relevant experience.

Structuring by means of the interview guide was primarily done in the interest of completeness, but in no sense precluded more wide-ranging consideration of transfer problems. Interviewees were encouraged to express any and all opinions, even those only peripherally related to the central concern of the study.

Administration of Questionnaires and Conduct of Interviews

The questionnaire was designed to be self-administered. During development it was pretested on a sample of broadly experienced SRI engineers and managers to insure that the items were clear and would not require checking back with those who prepared the questionnaire. Research personnel visited each company to arrange for the distribution of questionnaires and the conduct of interviews. The questionnaires were then distributed through company mail and were returned to the project director by each individual through U.S. mail in a stamped, self-addressed envelope provided with each questionnaire. Anonymity was preserved by specifying that names were not to be put on the questionnaires. This also made it impossible to send specific follow-up requests to those who had not returned the questionnaire after an appropriate amount of time. However, in spite of this limitation, the response rate was 60 percent, considered satisfactory for a mail-return survey of this kind.

Most of the interviews were conducted by two senior SRI researchers functioning as a team. Three such teams were used in this process. As previously mentioned, most of the interviewees had filled out questionnaires prior to the interview and, in the analysis, the questionnaires and interview responses were keyed together so as to permit cross-comparisons for each individual.

Data Collection, Processing, and Analysis

The questionnaires were designed to permit easy transfer of the response data to punch cards after open ended items had been coded. The basic analysis consisted of a computer breakout presenting a comparison of the various transfer and nontransfer groups on the questionnaire items. For example, relative proportions of various engineering specialties were compared between those groups that had made defense-to-commercial transfers and those which had not. It was thus possible to determine, for example, whether there were disproportionate numbers of electronic engineers among transferees as compared with nontransferees, which would provide one key to the potential transferability of electronics engineers. Similar comparisons were made on all other items.

A second analysis compared the opinions as to ease of transfer of those who had made transfers and those who had not in terms of various categories of characteristics such as engineering specialty.

As previously mentioned, the groups specified in the original analysis are as follows:

Engineers now in commercial jobs who:

Group 1 -- transferred to them from defense jobs in the same company

Group 2 -- transferred to them from defense jobs in different companies

Group 3 -- have had no previous defense experience

Engineers now in defense jobs who:

Group 4 -- transferred to them from commercial jobs in the same company

Group 5 -- transferred to them from commercial jobs in different companies

Group 6 -- have had no previous commercial experience

And engineers who:

Group 7 -- are now in nondefense government work.

The tabular computer printouts were arranged so that the data for each of the above groups were presented in columns. After the first computer run-through it was noted that the response patterns of Groups 1 and 2 (intra-and inter-company transfers from defense to commercial work) were similar, as were those of Groups 4 and 5 (intra-and inter-company transfers from commercial to defense work). Groups 1 and 2 and Groups 4 and 5 were, therefore, combined in order to simplify their presentation in the tables (Appendix B). By reading across columns, the response percentages for each of the five resulting groups may be compared. For those items in which there were no notable differences among the groups, tables are not presented.

The interview data were summarized after appropriate categorization by subject area and specific item, and not subjected to further statistical analysis.

The data and other information obtained from both engineers and managers who participated in the study are discussed in the next section of this report in terms of potential barriers to transfer from defense to commercial work and facilitating factors or potential aids to transfer.

V BARRIERS AND AIDS TO TRANSFER

The problem of transferability of individuals from one kind of work to another centers around both environmental and individual characteristics. The hypotheses stated in Section III of this report concern both these aspects of the matter and the engineer questionnaire was designed to probe both aspects.

The primary analysis of the questionnaire data provides comparison of various occupational groups on individual and environmental characteristics, attitudes and opinions relevant to barriers to transfer, and means of overcoming them. Through this analysis, differences and similarities in defense and commercial environments and in the individuals who are functioning in those environments can be specified with some precision.

Engineers' Data, Opinions, and Perceptions

The questionnaire responses by individual engineers have identified certain areas of possible concern regarding barriers to transfer.

Demographic Characteristics

In characteristics such as age, marital status, and numbers of dependents, no significant barriers to transfer can be detected in the study data, although previous studies have found some of these factors to be related to re-employment after layoff. In this study, the characteristics of those who had transferred are similar to those of the engineers who had not.

Education

The data suggest that there may be some differences between the defense and commercial areas in knowledge and skill requirements, although they do not appear to be of major consequence as deterrents to transfer. Advanced degrees are more common among defense engineers (Table 1), implying that skill requirements in the commercial area are generally lower than in the defense sector. The unwillingness or inability of commercial industry to pay for higher level skills that may not be needed could be a potential barrier, however. If the higher educational level implies greater specialization, some reorientation toward more general skills might be appropriate as a part of the transfer process, but overspecialization does not appear to be a major problem in any case.

Engineering Specialization

There is a suggestion of some imbalance in requirements for different specialties in comparing data on engineers now in the defense with those in the commercial sectors (Table 2). Defense industry may require larger proportions of electronics and aeronautical engineers than does commercial industry, and proportionately fewer mechanical engineers. The discrepancy is not large, but it implies some possible difficulty for electronics and aeronautical engineers in making the transfer because of somewhat lower demand for their specialties in commercial industry as it is presently constituted.

Two items in the questionnaire check list relate to specialization. Engineers were asked if they felt that there might be different specialty requirements in the defense and commercial fields and if this would be a problem in transfer. More than half of all groups felt that it might be a problem, but most of them did not feel it very strongly (Table 3).

Engineers were also asked if a possible requirement for more generalists in commercial industry as compared with the defense sector would be a problem. About 58 percent of the total sample felt that there might be a problem, but the strength of the feeling was not great (Table 4).

The lack of school courses in business administration, management or industrial engineering has presented no apparent barrier to transfer, since the proportions of defense and commercial people having had such courses are similar. Some engineers, however, feel the need for such courses as expressed in an item in which they were asked what kinds of training courses might be necessary in preparing them for defense-to-commercial transfers (Table 5). About 40 percent of both transfer groups felt that no special courses or only on-the-job training was required. The nontransfer groups are somewhat less confident, since only about 27 to 31 percent gave the no-requirement or on-the-job training response. Compared with the other groups, rather more of the defense group that had had no previous commercial experience--and more of the nondefense government engineers--feel the need for additional courses. Among those who have actually transferred, some feel a need for courses in manufacturing, production or industrial engineering, or consumer product oriented courses; somewhat fewer would like courses in cost accounting or other subject areas.

Work Functions

A potential barrier is the relative difference in engineering work functions between defense and commercial industries. The former appears to make more extensive use of engineers in systems analysis and system design activities (Table 6). If such skills are less in demand in the commercial sector, potential transferees may have to adapt to or be reoriented in other directions. Defense engineers in other functions, particularly those who work on component or equipment design, should have fewer problems in transferring to commercial industry since it uses relatively more of such people than does defense industry.

Attitudes regarding differences in work functions were expressed on two of the check list questions. Engineers were asked if they felt that there might be a transfer problem because of a greater requirement for customer relations and "tech rep" work in commercial industry than in the defense sector. More than 50 percent of all groups felt that this would not be a problem, and there were no great differences between transfer and nontransfer groups.

Engineers were also asked if they felt that a possible requirement for more knowledge of specific product lines in commercial industry would be a transfer problem. A problem was seen by less than 50 percent of all groups. Differences between transfer and nontransfer groups were small.

Levels of Supervision

One item indicated engineers' experiences concerning levels of supervision in defense and commercial work. Of those groups having had both experiences, 55 percent or more feel that they are about equal. There is no implication of any barrier to transfer in these data.

Several questionnaire items deal directly with transfer experience. In one (Table 7) the engineers who had ever made the change from defense to commercial work were asked if that change was more or less difficult than changes they may have made from one defense job to another or from one commercial job to another. From 70 to 74 percent of them felt that the level of difficulty was about the same; the 74 percent applies to the transferees now in commercial work. There is no evidence from these data, therefore, that defense-to-commercial transfers are any more difficult than other kinds of transfers.

Cost-Consciousness and Product Reliability

Perceptions, attitudes, and orientations on the part of engineers may be barriers to transfer. A number of questionnaire items were used to probe this area. One of the ideas that has gained great currency in the last few years is the supposed lack of cost-consciousness on the part of defense engineers and the greater requirement for cost-consciousness in commercial industry. Table 8 presents data relative to this matter. About four-fifths of the total sample of engineers regarded this as a transfer problem, with no great differences in opinion among the various groups. Thus, differences between the defense and commercial sectors in dealing with cost considerations may be a serious problem in transfer.

Related to the matter of cost is the degree of importance of product reliability in the two environments. It has generally been assumed that defense requirements for reliability were substantially higher than commercial requirements, and that, therefore, reliability and performance rather than cost were primary considerations in the defense sector. Conversely, it has been argued that commercial industry cannot afford extraordinarily high degrees of reliability and that engineers who try to transfer might have difficulty in adjusting themselves to the changed requirements. Table 9 indicates that more than half the entire sample (57 per cent) feel that this would not be a transfer problem. Larger proportions of the groups now working in defense see this as a problem than do the commercial groups, but a clear majority of those now in commercial work do not feel that excessive defense concern with reliability is likely to be a problem in transfer.

Job Satisfactions and Hopes

The different amount of interest and challenge in the two kinds of work has also been thought to be a possible barrier to transfer, since defense work is usually regarded as more interesting and challenging than commercial activities. Table 10 presents data relative to this question. Among those who have a basis for comparison, the commercial engineers see their work as either about the same in interest and challenge as that of defense engineers or more interesting and challenging, while defense engineers tend to see their work as the more interesting and challenging. Thus, there is no apparent barrier to transfer in this regard.

Less than 25 percent of any group feel that they have not been given proper recognition in their present jobs, and there are no great differences among the various groups in this respect.

Overall job satisfaction is similarly high in all groups (less than 10 percent express serious dissatisfaction), and there are no defense-commercial differences of consequence. Thus, there is no evidence that lack of recognition or general job dissatisfaction are transfer problems.

The area of future occupational plans was also explored in the questionnaire as a possible source of inferences regarding past experiences in defense and commercial work and willingness to transfer in the future.

In one such item (Table 11) engineers were asked what they hoped to be doing ten years from now. The alternatives included various combinations of working for their present or different employing organizations and working in defense, commercial, or nondefense government work. Working in business for oneself, or retired or otherwise not working for pay, were also possible choices. The most striking finding here is that more than 60 percent of all the commercial engineers hope to be working for their present organizations in commercial work and another 17 to 22 percent hope to be working for a different organization in commercial work, while very few present commercial engineers want to be in defense or nondefense government work for any organization. In contrast, only about 34 to 40 percent of the present defense engineers hope to be doing defense work in their present organizations, with an additional 6 to 12 percent hoping to be doing defense work in a different company. In addition, 8 to 15 percent of the defense engineers hope to be with their present organizations in commercial work and another 9 to 10 percent hope to be with a different company in commercial work. Larger proportions of defense engineers than of commercial engineers hope to be in nondefense government work in their present companies.

Taken together, the above findings indicate a clear preference among those who have made the transfer to commercial work to remain in it and a willingness on the part of many defense engineers to undertake something other than defense work in the future, although they are satisfied with their present jobs. Thus, motivational and attitudinal factors appear to support transfer rather than deter or oppose it.

Table 12 presents data relative to hopes for future supervisory or managerial positions. Some 75 percent of the total sample hope to go into such work in engineering or a related field in the next ten years. Slightly fewer of the defense engineers express this hope than do commercial engineers, and defense engineers also show somewhat greater proportions expressing a hope to be in some other line of work.

A question about reasons for leaving defense engineering jobs in order to take commercial positions was asked of all those who had ever made such a transfer. The question was open ended, and only the responses of those who are recent defense-to-commercial transferees are reported since there were only scattered responses in the other groups. For those engineers who transferred within their companies, the most frequent response can be described as "a voluntary or involuntary change within the same company," which does not, of course, report a reason but only that such a change was made. "Layoff, cancellation or the end of a contract" is given as the next most frequent reason, followed in decreasing order by "greater opportunity, challenge or a better job," "job security or stability," and "dislike for red tape, paper work, or war work." For the group transferring from one company to another, the most frequently given reason is "greater opportunity, challenge, or a better job." This was followed in decreasing order by "job security or stability," "layoff, cancellation or end of a contract," "dislike for red tape, paper work, or war work," and "money."

Managers' Attitudes

A check list item provided data on engineers' estimates of the probable significance to transferring of commercial managers' attitudes (Table 13). Previous research indicates that some commercial managers would be unwilling to hire defense engineers because they feel such engineers are not cost-conscious and might tend to over-engineer. Except for commercial engineers who have had no defense experience, a clear majority (61 to 76 percent) of commercial, defense and nondefense engineers feel that such managers' attitudes might be a problem. The feeling is held by somewhat larger proportions of defense engineers than of commercial engineers among those who have had both experiences. This suggests that such managerial attitudes might indeed be a barrier to transfer.

Serious Transfer Problems

After having been asked for an estimate of the seriousness of various transfer problems, engineers were requested to state which one of the previously mentioned problems would be most serious in the event of a large scale transfer from defense to commercial work. Data on this item are presented in Table 14. For each group the responses have been ranked in terms of the number of engineers who rated each problem as being the most serious. The rankings are similar for all groups. The largest proportion in every group ranks "more emphasis on cost factors in commercial engineering" as being the most serious problem. "Managers' beliefs that defense engineers are not well suited to commercial work" is rated second in importance by both defense groups as well as the nondefense government group, whereas both groups of commercial engineers gave second place to "requirements in commercial work for more engineers who are broad generalists," a problem ranked fourth by defense engineers. Another problem area--"commercial requirements for engineers in different specialities"--was ranked third or fourth by all groups. These four factors, thus, should be considered as possible barriers to transfer.

An open ended question asked simply for "any additional comments" engineers might have regarding serious problems or obstacles to large scale transfer from defense to commercial work. The wide range of responses showed no great concentration on any point and no great differences among groups in frequency of mention of various kinds of problems. Differences in the work itself, the inability of commercial industry to support so many engineers, the need for retraining and reorientation, salaries, and the statement that there are no serious problems were most frequently mentioned. Only the first was stated by as many as 23 percent of the entire sample, with the others ranging down to 10 percent. No striking areas of concern different from those already identified in other parts of the questionnaire were detected.

Ease of Transfer

Two questionnaire items concerned engineers' estimates of ease of transfer. In the first of these, engineers now in defense were asked how easy they thought it would be for them to transfer to commercial engineering activities in another part of their present organizations, assuming that jobs were open in those activities. Only about one engineer in five now working in defense industry feels that transferring to commercial work would be "not very easy" or "practically impossible." In the second item, engineers who have made the defense-to-commercial transfer were asked how easy it was for them to make the change. Less than one in twenty said that it was "not very easy" and less than one in one hundred said that it had been "extremely difficult."

These two items having to do with ease of transfer were subjected to a further analysis in order to place the responses in various other categories such as age, specialty, and work function. In general, differences in distribution on the subcategories were small. For example, no one group of engineers by function feels appreciably less confident of its ability to transfer than any other. The same relationship holds for those engineers who have already made the transfer.

Although there are great similarities in distributions on most of the items pertaining to confidence or ease in transfer, certain suggestive trends may be observed. The longer an engineer has been in defense work, the more likely he is to feel that transfer would be difficult. For those who have already transferred, electronics engineers thought it was more difficult than did those now employed as mechanical engineers. This is in accord with the finding reported earlier that there were more mechanical engineers among those in commercial work than in defense work. Those with doctor's degrees are somewhat more confident of their ability to transfer than other categories but a more interesting finding is that those without degrees of any kind are as confident as holders of bachelor's and master's degrees.

Managers' Opinions and Perceptions

About 100 engineering managers in the 14 firms that participated in the study were interviewed. The interviews occupied 45 minutes to an hour each and were in considerable depth. An interview guide (Appendix A) was used to structure the interviews in content and sequence, but ample time and opportunity were provided for any additional responses managers might want to make. Most of the managers had had responsibility for both defense and commercial work in the course of their careers, and most of them were trained and had worked as engineers. In addition, a number of personnel managers and training officials were interviewed.

The general attitude expressed by the managers on the subject of transferability might be characterized as one of cautious optimism over the skills and attitudes of individual engineers, but of some concern regarding the ability and willingness of the commercial sector to absorb large numbers of defense engineers without economic help and some reorientation of thinking.

Managers' comments are discussed here as they relate to various aspects of transferability.

Cost-Consciousness and Product Reliability

Substantial numbers of managers feel that commercial engineers must be more cost-conscious than defense engineers. Many point out, however, that the commercial and defense sectors are coming closer together with respect to both cost and reliability considerations. In the process of bidding on defense contracts, cost enters in, in a very fundamental way. On the commercial side, particularly in the area of producer or capital goods, some customers demand excellent performance and reliability and are willing to pay for it. Many consumer goods customers also require better performance than was the case a few years ago so that, even in highly competitive situations, it may be possible for a company to recover the additional costs of careful design and production. Most managers feel that there is now very little difference between defense and many parts of the commercial sector regarding performance and reliability.

It is pointed out by a number of managers that defense specification requirements are often excessively high, that high costs go with them and, therefore, defense engineers have developed habits of overdesign and of getting the last fraction of performance-improvement regardless of cost. Most managers state also, however, that an engineer designs to the specifications he has been given and that, if such specifications are less rigorous in the commercial sector, engineers would be able to adjust to the changed requirements. Cost-consciousness is a habit and habits can be changed, although generally with some difficulty. Many defense engineers are given cost objectives. The aim may not be the lowest cost, but cost is a trade-off. In military work, cost considerations enter programs in later stages than is the case in commercial work, but they are present in both fields. Defense engineers may not be familiar with the cost ramifications of mass production, but they are conscious of the cost of design changes.

Finally, several managers assert that concern with cost is more often the business of the manager than of the individual engineer, so that it should not be a major transfer problem.

Skills and Specialization

It is almost universally agreed among managers that the level of technical skill would not constitute a serious barrier to transfer, since technical levels are generally higher in defense work. Upgrading of skills through training or other means would not, therefore, be required. As presently constituted, commercial industry might not make full use of the technical skills of defense engineers, but if and when it is ready to do so, those skills should increase the efficiency and effectiveness of commercial operations substantially. It was stated by one commercial manager in a company whose work is 95 percent commercial and which turns out complicated and high quality products, that the influx of defense-trained engineers to the company which had greatly expanded in the last five years had been enormously beneficial on the technical side, particularly with reference to reliability, quality assurance, and planning functions. Other managers agree that those companies willing to make full use of defense engineering talents and techniques would find it very profitable to do so.

Related to the question of technical skill is the matter of overspecialization. Many managers assert that there are differences between defense and commercial work on this dimension. Defense engineers do tend to be more specialized and to work on limited segments of systems in which their specialties are fully used. Commercial engineers, on the other hand, are more likely to be concerned with an entire process from raw material to loading dock. Theirs is a product orientation. Even though this may be the case, however, it was not regarded as a serious transfer problem since many engineers, if properly motivated, could readily learn to broaden the scope of their concern. Few, if any, additional technical skills would be required in this reorientation.

Managers generally agree that different marketing skills would be required of defense engineers who transferred to commercial work. This is primarily a matter of specific product orientation and is related to the commercial practice of requiring engineers to be concerned with all aspects of product development from design through manufacture. Defense customers are generally very sophisticated. They can specify precisely what they need and want. This is much less true of most commercial customers, although greater sophistication has developed in some groups in recent years. The commercial engineer who has some marketing functions must, in general, have more highly developed communications skills in order to deal with customers who cannot specify their requirements with sufficient clarity to permit precise cost and scheduling estimates. The entire matter of developing marketable new or old products is one in which most defense engineers are not experienced or knowledgeable.

Work Functions

Differences in work functions in the defense and commercial sectors do not, in the view of many managers, constitute serious deterrents to transfer. Some of the functions now carried out in defense, as pointed out above, could usefully be brought into the commercial world. For example, defense engineers consider human factors much more in designing than is usually the case with commercial engineers. Defense engineers would probably be best suited to R&D, new design, advanced engineering, and analytical areas. Large projects requiring a team effort would also be appropriate. Innovation, new product development, and systems design in the commercial sector are directly relevant to defense experience.

There are two work function areas which may pose more serious transfer problems. One of these is documentation and related functions. Defense industry employs great numbers of individuals who are trained as engineers but who do not perform conventional engineering activities. They write specifications, handbooks, and manuals. Their functions relate to quality assurance, reliability engineering, and value-engineering programs. They are involved in program and configuration management activities. In order to perform many of these operations, personnel usually have engineering degrees or must be trained as engineers. As it is presently constituted, there is no place for the bulk of these people in the commercial world. Managers give estimates ranging from 10 to 60 percent of the total engineering force in defense industry as being engaged in these activities. For example, some $500 million went into total engineering activities in two military missile systems. There were several thousand documentation engineers in these programs. No commercial operation, even one in capital goods production, requires or could afford such costs. In commercial microwave communications, for example, some 300 professionals were said to handle all technical work with 2,000 support people. The problem has two aspects: commercial industry does not need such large numbers of peripheral engineering personnel, and could not afford them if it did. Thus, in the event of marked declines in defense spending, there might be a great many trained engineers who could not switch to commercial industry without substantial retraining or refresher courses in engineering. Great increases in the need for these work functions is unlikely in the commercial sector. It should be noted that the figures used above are managers' personal estimates but, even if considerable allowance is made for error, the problem may be a serious one.

The second problem in work function areas is related to the one just discussed, but is particular to aeronautical engineering. Most aircraft engineers who are not now working on aircraft design and production have been absorbed in military and civil space programs and would have to be reabsorbed in commercial fields in the event of military cutbacks. In addition, there are still large numbers of aeronautical engineers working in manned aircraft programs. Military aircraft production will probably decline and commercial aircraft production requiring large amounts of high level engineering input (with the exception of the SST Program) is leveling off. Thus, there may be a good many more individuals displaced in this engineering specialty than the civil space program can absorb. This would seem to call for retraining and reorientation on a fairly large scale, since there are about 40,000 aeronautical engineers in defense work.[12]

Some managers estimate that substantial numbers of aircraft engineers are also documentation engineers, which complicates the problem still further. Additional study would be required to determine how extensive specific retraining requirements might be and how they might be handled.

Job Satisfactions and Salaries

Another major area about which managers were asked was that of interest and challenge in defense and commercial engineering, aspects that could affect motivation and willingness to transfer to, and performance in, commercial jobs. The general feeling of most managers is that there is less technical challenge in commercial work but a great deal of challenge in considerations of manufacturing feasibility and the balancing of cost and performance. The challenge is of a different kind but of no less magnitude.

Some managers feel that defense engineers are held more accountable for what they do, for producing to schedules and the like, and that this is a challenge in itself.

But many defense engineers, managers feel, are attracted by elegance and sophistication in problem solutions and by working close to the limits of the state of the art. There is less glamor and more "nut-and-bolt" engineering in commercial work. Many defense engineers do not see themselves as designers of consumer goods. Some find it less interesting to design equipment than large-scale systems. However, if commercial industry is willing to accept the creative, innovative man he can be useful and both interested and challenged by many commercial problems.

In part, the problem may simply be one of lack of knowledge on the part of defense engineers of the kinds of jobs they might be called upon to do in commercial industry. The challenge and interest are there if the engineer is prepared to look for them. According to managers, many engineers who are now in commercial work, including both those with previous defense experience and those without it, find their commercial activities intensely interesting and challenging. The questionnaire data on engineers reported earlier support this managerial opinion.

Salaries are believed by managers to be higher in the defense sector for comparable training and experience.

Transfer Problems and Experiences

Those managers who filled out the questionnaire ranked "cost factors", "managers' beliefs as to ability of defense engineers to function effectively in the commercial sector," "need for generalists," and "knowledge of specific product lines" as being the more serious transfer problems. Their rankings are similar to those given by the engineers (Table 14).

Managers were asked about their actual transfer experiences and those of their companies. General opinions are that organizations cannot be converted from defense to commercial work without great difficulty, but individuals can. In forming a new commercial organization, a cadre from a defense division may be set up first, and then others are brought in slowly so that they learn by osmosis or absorption. The transfer of technical skills has not been a major problem in most instances, expecially if defense and commercial products are similar. In those jobs for which skills related to marketing are required, it is another matter and training on the job may take several years.

Many managers feel that transfer of defense engineers has benefited commercial industry highly by bringing in more advanced techniques and technology. This opinion is based on experience both of in-company transfers in setting up new commercial divisions and of transfers from other companies.

The following represent specific examples of transfer experiences and managers' opinions regarding them:

1. A control system division of an electronics firm was started four years ago by transferring about 20 defense engineers who were selected on the basis of their specialties, and hiring some specialists from outside. Most had had previous commercial experience. Key personnel were transferred first. On-the-job-training and company courses were used to meet the new requirements, which were primarily in the area of product orientation. The transfer was judged by managers to have been successful.

2. An entire department of a mechanical equipment group was transferred from defense to commercial work. The manager was transferred first, and he set up the organization and assigned the

> engineers to particular jobs. Engineering specialty requirements were different and it took 15 months for the engineers to become familiar with the new line. During that time, in-plant courses in production planning, production control, inventory control, economical product design, cost analysis, and accounting were given. The average cost of the training was $8,000 per engineer. The courses, with the exception of accounting, were given in the plant by an outside management consulting firm. The training was felt to have been effective, although no formal measures of performance were made. The managers' estimate was that a substantial proportion of the defense engineers who had been selected while still in defense work were able to perform well in the new environment after the training.

The latter case tends to refute the notion that entire departments cannot be transferred, but it should be noted that great cost and effort were required.

During the planning of this study, it was thought that there might be some legal or administrative barrier to transfer in the areas of company policy, licensing, or union membership. No managers expressed beliefs that such deterrents existed, and there is no evidence from the questionnaire data that this is the case.

VI DEFENSE ENGINEERS COMPARED WITH COMMERCIAL ENGINEERS

Relevant group differences are discussed below in terms of the variables relating to transferability.

Engineering Field

Table 2 shows that only 27 percent of the commercial group without previous defense experience are electronics engineers, while 45 percent of of the defense group without previous commercial experience are electronics engineers. Thus, electronics engineers in this sample comprise a larger proportion of the defense workforce than they do of the commercial workforce. The reverse is true of mechanical engineers. This suggests, as previously mentioned, that transfers might be somewhat more difficult for electronics engineers and less difficult for mechanical engineers.

Additional data on this point are in Table 15, which shows the specialties in last previous defense employment. The proportions of the various comparison groups are fairly similar but with a higher proportion of mechanical engineers in the commercial group than in the defense groups.

Specialties in the last previous commercial employment are similar in distribution for all comparison groups.

Work Functions

As previously mentioned (Table 6), larger proportions of the defense engineers are engaged in activities labeled as systems analysis and/or design than is the case for commercial engineers, and larger proportions of commercial engineers than of defense engineers are working on component and/or hardware product design. These data point to certain differences in design functions and environment and in the required skills that may be relevant to transferability.

Among defense-to-commercial transferees, the proportion having previously been employed in defense component and/or hardware product design is higher than it is among present defense employees (Table 16). This again suggests a somewhat higher demand for engineers in this functional category in commercial work, and therefore easier transfer for this type of engineer now in defense work.

No clear-cut differences in distributions with respect to work functions in previous commercial employment for the various comparison groups were found.

Supervisory Factors

The findings with respect to present supervisory activity (Table 17) show few clear-cut differences between the defense and commercial sides. However, when the age variable was controlled, by considering only those engineers over 40 in a special analysis of the study data, it appears that there is considerably more supervisory activity among defense engineers.

Less than 40 percent of the total sample had had supervisory responsibility in defense work before their present jobs (Table 18) and the differences among groups were not great, although there is a somewhat greater tendency for the defense group with previous commercial experience to have had both project and "permanent" group supervisory responsibility. Less than 34 percent in any group had had supervisory responsibility in commercial work before their present jobs, and no clear group differences are discernible.

Supervision appears to be somewhat closer in commercial work (Table 19) but in both defense and commercial activities, 76 percent of the total sample feel that occasional consultation is the usual pattern.*

Larger proportions of those who transferred from defense to commercial work than of those now in defense work felt they were closely directed by their last defense managers (Table 20). However, about 51 percent of the total sample reported that occasional consultation was the norm. Similarly, somewhat larger proportions of those now in defense than of those transferred from defense to commercial felt they had close direction of work by the previous commercial manager (Table 21). As in the previous instance, closeness of supervision may have been one motivation to transfer, but it appears to apply to transfers in either direction.

---

* See the last part of Appendix C for comparison of these data on engineers with data on scientists from another national survey.

Organizational Identification

Commercial engineers appear to have a slightly stronger identification with their present employing organizations as compared to their engineering professions than do defense engineers, but from half to two-thirds of all groups identify more strongly with their present employing organizations than with their professions (Table 22).*

Professional Identification

There are no differences in the proportions of defense engineers and of commercial engineers belonging to professional engineering societies.

Less than 50 percent of all groups attended any professional engineering meetings away from their home cities in the last year, and in this measure also there are no clear defense-commercial differences.

In all groups, 83 percent or more are not licensed or certified by any state, and again there are no discernible defense-commercial differences in this respect.

Years of Experience

The median of the defense-to-commercial transfer group is 10 to 14 years of experience in all engineering work and the nontransfer commercial group 5 to 9 years. The median for the defense transfer group is in the 15 to 19 year category and for the defense nontransfer group in the 10 to 14 year category. There is no indication of a relationship to transferability.

Age

The median age for the defense-to-commercial transfer group is in the 35 to 39 bracket. For the commercial-to-defense group it is in the 40 to 44 bracket. The two nontransfer groups have medians in the 30 to 34 bracket (Table 23).

---

* See the last part of Appendix C for comparison of these data on engineers with data on scientists from another national survey.

Marital Status and Dependents

Eighty-eight percent or more of all groups are married. The median number of dependents for the engineers in all groups is three.

Salaries

In the commercial groups, median annual salaries are in the $13,000 to $14,999 bracket (Table 24) for the transfer group, and in the $11,000 to $12,999 bracket for the nontransfer group. The median for the commercial-to-defense transferees is in the $13,000 to $14,999 classification, as is that for the other defense group. There are no very clear cut differences related to the defense-commercial dichotomy, but of the two nontransfer groups, the defense one is more highly paid.

Education

Comparison of commercial with defense groups indicates that there are more doctor's and master's degree helders among the defense groups and, correspondingly, more bachelor's degree holders among the commercial groups (Table 1). As previously mentioned, the general educational level is slightly higher among defense than among commercial engineers.

In addition to the previously reported item in which engineers were asked to indicate the specialty fields in which they are now working (Table 2) and had previously worked in defense (Table 15), there was a questionnaire item in which they were asked to report the specialty field of their highest degrees. Table 25 indicates that the proportions for the various groups by highest degree specialty are fairly similar except that mechanical engineers are more heavily represented in commercial work than in defense work. This again suggests, as did the findings on the previous items regarding specialties, that mechanical engineers may find transfer somewhat less difficult because of the relatively greater demand for them in commercial industry.

There are no consistent differences between defense and commercial groups as regards the year in which the highest degree was received. All medians are in the 1951 to 1955 or 1956 to 1960 brackets.

The educational institutions from which the highest degrees were received were categorized as universities, colleges, engineering technical schools and a number of others, including one for the top nine engineering

2

schools as rated by a special committee of The American Council on Education. The last category includes institutions which would otherwise be designated as universities or engineering technical schools. Fifty-four percent of the total sample received their highest degrees from universities (Table 26). The proportion of those receiving their highest degrees from the top nine institutions is somewhat higher in the defense groups than in the commercial groups, and commercial groups are higher in the category of engineering technical schools and military academies.

Forty-eight percent or more of all groups had no school courses in business administration or management, and there are no discernible defense-commercial differences. More than 59 percent of all groups had had no school courses in industrial engineering, and again there are no observable defense-commercial differences.

Employer Courses

With regard to taking any courses that may be given by the present employer, 37 percent or more of all groups had had none. The commercial groups have had somewhat more than the defense groups (Table 27). Seventy percent of the total sample had taken no courses from past employers (Table 28).

Summary

General background, education, and experience characteristics of defense and commercial engineers and defense and commercial environmental factors have been compared in this chapter as one means of gaining insight into the problems of transferability from one milieu to another. There are no great differences between the defense and commercial sides as regards the environmental and individual characteristics considered in this study, but some suggestive findings have appeared.

Mechanical engineers make up a larger proportion of the commercial engineering workforce than of the defense engineering workforce. The opposite is true of electronics engineers. This imbalance has some implications for skill transfer and perhaps for required retraining to facilitate transfer.

Systems analysis and design are engaged in by larger proportions of defense engineers than of commercial engineers. Contrary findings apply to component and hardware product design. Here again is a difference which might be balanced by retraining or reorientation.

There is some suggestion that a possible motivation for transfer in either direction is over-closeness of supervision.

The educational data suggest a somewhat higher technical level for defense engineers which may in turn imply greater specialization. To the extent that degree of specialization may be a barrier to transfer, this identifies a possible area of concern. Related to the same point is the finding of a larger proportion of graduates of top rated engineering schools among defense engineers.

Slightly larger proportions of the commercial groups have had courses given by their present employers than have defense groups.

VII RETRAINING AND REORIENTATION FOR TRANSFER

The types of retraining and reorientation activities that might be carried on as an aid to transfer include (1) in-house programs, (2) programs in existing public and private educational institutions, and (3) community programs under joint public and industry sponsorship.

Both individual engineers and managers agree that where technical training or retraining is needed at all, it should be carried out in-house and that, with few exceptions, it should be of an on-the-job variety. Engineers generally regard themselves and are regarded by managers as professional personnel who do not require formal courses to fit them for new or different jobs. General upgrading might be accomplished through the use of formal courses, but such retraining as is required in transfer is best handled on an interpersonal basis on the job.

When engineers come into a commercial environment, they should be absorbed over a period of time and learn any new skills through direct contact with those engineers already in the commercial work. This is best accomplished if only a few engineers are transferred at a time.

If a new commercial enterprise is being started, there should be a cadre of highly skilled people to get it underway. It may be desirable to bring in a few specialists or consultants to aid this initial group. As additional engineers are brought in, they will learn from those already there. This process may be slow, but it is effective and economical inasmuch as the man can be productive as he is learning.

An essential part of on-the-job training is a design review process whereby senior individuals can point out where the designing may have gone wrong. The process is not unlike that used with any young engineer just out of school on his first job. In school, he learns more theory, less practical design engineering having to do with component choice, manufacturing feasibility, cost, and the like. These things can best be learned on the job, and the same applies to most transfer retraining.

Attitudes, such as those relating to cost-consciousness and reliability, cannot be successfully altered through formal training, in the view of most managers, but they may be changed as an engineer is absorbed in his new environment. The same is true with respect to product orientation, which is regarded as essential to successful transfer by many managers and individual engineers.

It is noted by some managers that if the mix of specialties in defense and commercial industry is markedly different, more extensive training might be required. Some specialty changes might be almost impossible, while others could be accomplished if sufficient time and money were provided. The participation of universities and technical schools might also be desirable. Related to this is the problem of retraining or upgrading the large numbers of documentation engineers in defense industry, which might require more elaborate training programs with some public assistance because of the large numbers of such engineers.

University personnel interviewed tended to focus on technical skill as a possible problem area and suggested formal training. As noted above, most managers in industry did not favor this solution. University people showed little concern or awareness for the practical problems of reorientation to commercial environments.

VIII DISCUSSION OF FINDINGS

The Disarmament Situation

At least two kinds of situations might occur as a result of the negotiation of arms control or disarmament agreements. One would be a sharp drop in defense spending with a very limited probability of return to defense jobs in the future. The other would be a slow decline in defense spending with some cyclical effects such as those which have occurred in recent years. Of the two possibilities, the latter is the more likely to occur. Experience with cutbacks in particular contracts that have been made in recent years affecting large prime contractors and their subcontractors, indicates that dislocations can be severe in their effects on substantial numbers of people even in these instances of limited shifts in defense budgeting. It appears, therefore, that even under conditions of a slow decline in defense expenditures, the amelioration of deleterious effects both on the individual and on the economy would be a proper concern of government and private institutions.

The focus of the present study is on individual adjustments in the area of skills and attitudes and not on economic considerations, although these have not been ignored.

Significant Barriers and Aids to Transfer

The findings suggest that attention should be given, in planning, to a number of skill and attitude areas.

Defense industry appears to make more use of electronics engineers and less use of mechanical engineers than does commercial industry. This imbalance, while implying a more rapid absorption of mechanical than of electronics engineers in commercial industry, presents barriers to transfer for some types of engineers that might have to be overcome by some form of retraining or reorientation. Both individual engineers and managers see a possible transfer problem arising out of differences in required specialties in the two environments.

Some managers feel that aeronautical engineers would have a particularly hard time in making a transition because of a limited demand for them in commercial industry. The ease of convertibility of aeronautical engineers to other fields could not be studied in depth in this research effort and has not previously been studied systematically, so no assessment of the magnitude of the problem can be made at this time.

A possible barrier is reflected in the opinions of many engineers and managers that more generalists rather than specialists may be required in commercial industry. Both opinions and the objective evidence of a somewhat higher educational level in defense sector suggest that there may be a degree of overspecialization in defense that is reflected in a tendency to push the limits of the state of the art and might bring about an unwillingness on the part of some engineers to concern themselves with some of the more mundane aspects of commercial engineering having to do with production and the like. In a time when defense jobs are in short supply for a considerable period, it may be assumed this would not be a serious barrier and that most engineers would be able to reorient their thinking as required to take more general roles and develop a product orientation.

The matter of higher technical skills and specialization in defense industry may have positive as well as negative aspects. It is a commonly expressed opinion among those participating in the study that defense skills would be most useful in the technical upgrading of commercial industry through application of techniques developed in the defense sector and that, in the long run, commercial industry would profit greatly from making use of those skills, especially in the area of new product development.

Stretching the limits of the state of the art in defense industry is often the result of an attempt to squeeze the last fraction of performance and reliability from a system. This is costly. The tendency to work toward high performance regardless of cost is a possible barrier to transfer since commercial industry may not be able to afford such an orientation. Large proportions of engineers feel that this would be a transfer problem. Many managers, however, pointed out that cost is becoming more of a consideration, at least in bidding on defense contracts, and that reliability is becoming more important as a requirement in commercial industry. In any case, in the view of many managers, most engineers work to specifications, whatever they may be, so that the barrier might be reduced by a relatively easy reorientation of thinking.

Some lack of confidence in their training in certain areas was expressed by engineers, especially those with only defense experience. Those who have transferred stated needs for cost accounting, cost analysis, cost effectiveness, economics and manufacturing, production or industrial engineering as well as product-oriented studies. There is no indication, however, that the lack of these courses is a significant barrier to transfer, since there are no great differences in this regard between those who have made the transfer and those who have not. It would probably be desirable for engineers preparing themselves for possible transfer to try to acquire knowledge in these areas, but there is no indication from this study that it is essential.

There are potential barriers in the area of work functions. Systems analysts are more heavily used in defense industry than in commercial industry, and it appears that there is a greater need for component and equipment engineers in the commercial sector. Systems approaches to engineering problems are being taken in certain sectors of commercial industry, particularly in the area of producer and capital goods, but the demand at present may not be large enough to absorb great numbers of engineers now engaged in systems work in defense. The precise manner in which more systems talents might be effectively used in commercial industry awaits determination through further study. Experience in component and equipment engineering should be a facilitating factor in transfer in view of commercial requirements for such talents.

The work functions carried on by the large numbers of documentation engineers in defense industry may be the most difficult of all barriers to transfer. Commercial industry has expressed no great need for most of these functions and, in any case, cannot afford to support such activities on a large scale. In order to prepare this substantial segment of the defense engineering population for transfer, it will be necessary to determine what skills they possess that might be usable in nondocumentation functions in commercial industry and what sorts of additional training and orientation will be required to fit them for commercial jobs. They will be at a competitive disadvantage because of the nature of their experience, and it may require substantial efforts to provide for their effective transfer.

At the present time salaries may be a barrier to transfer, since indications are that they may be lower in commercial industry for comparable age, experience, and education. Compensating factors may include greater security and a liking for commercial work. It appears that in the event of limited availability of defense jobs, engineers might be more willing to accept lower salaries than is now the case, and that salary would not, therefore, be a significant barrier if defense cutbacks occurred. The three studies of cutbacks at Boeing, Martin, and Republic indicate that personnel were willing to accept lower salaries under the pressure of job scarcity.[1,2,6]

With regard to the general attractiveness, interest and challenge of commercial work, there appear to be no serious problems. Those now in commercial industry, by and large, hope to remain in it. Less than half of those now in defense industry express a hope to remain in it during the next 10 years and many express a preference for commercial work. There may be greater technical challenge in the defense sector, but other kinds of challenge exist in commercial work. Some engineers now in commercial work state as their reason for transfer the existence of greater challenge in the commercial sector. Certainly, if defense jobs were less available than is now the case, the level of interest and challenge in commercial industry even if it is lower would not be a barrier, and indications are that it may not be lower, but simply different.

The attitudes of commercial managers are felt to be a barrier to transfer by a good many engineers. Both defense and commercial managers see this as a problem also, although commercial managers see it as being less important than many other problems such as cost-consciousness. Greater acceptance of defense talents and an appreciation for the positive contributions of highly skilled defense engineers in commercial industry has been developing in recent years, however, and this change in attitude will probably continue so as to reduce the significance of this attitudinal factor as a barrier.

The lack of understanding of sales problems, customer demands, and commercial marketing structures related to the nonproduct orientation of most defense engineering is also a potential barrier to transfer. The required reorientation can probably only be carried out on the job, and this poses a problem of time and cost for commercial companies, the seriousness of which cannot be assessed at this time.

Significant Training and Reorientation Preparations

Planning for possible cutbacks in defense spending may be undertaken at several levels: that of the individual engineer; that of line, personnel and training managers; that of employing companies; and that of local, state, and federal governments.

The primary responsibility of the individual engineer is to maintain and enhance his technical skills in his own field and to try to diversify his skills and interest into other fields that might find appropriate use in commercial industry. The attitudinal changes that appear to be desirable cannot be brought about by formal training as such, but those attitudinal aspects related to such matters as cost-consciousness might be affected by self-study or course work in business subjects such as management, marketing, cost analysis and the like. Production and industrial engineering subjects would also be appropriate in preparing an individual for transfer. In general, individual engineers need to develop an awareness of the requirements of commercial industry as they may differ from those of defense industry, and this might be done through self-generated study programs.

There are some actions line managers might take to facilitate the transfer of engineers from defense to commercial work. Those who tend to feel that defense engineers have been spoiled for commercial work might try to adjust their attitudes in the direction of trying to make use of the special talents that defense engineers may have. Those who are in a position to influence their companies to undertake more R&D work of a commercially valuable kind could do so by trying to demonstrate that additional R&D might increase return on investment. In addition, line managers might participate in the development of on-the-job or after-hours training and orientation activities relative to their areas of expressed concern such as cost, manufacturing feasibility, and marketing.

Personnel managers are normally concerned with matching skills and jobs, with salary levels and the like. Within companies having both defense and commercial activities, they might begin the development of skills inventories, found to be valuable. They might also work with line managers to identify those skills of defense engineers in various specialties that appear to be readily adaptable to commercial activities and to determine how transfers between specialties and work functions might be effectuated. If, as seems likely, there are more similarities than differences in the two fields, an analysis of skills as just described would be helpful in getting commercial managers to accept defense engineers and to make the most effective use of those who joined their organizations. It would also make the hiring functions of personnel departments more efficient by specifying both job and individual skill requirements more precisely.

Training managers should concern themselves with developing effective means of preparing defense engineers for commercial jobs so as to make them useful members of the commercial engineering workforce in as short a time as possible. They should be aware that, for most purposes, on-the-job training, as indicated by managers in this study, is the preferred method to use in retraining and reorientation, and they might work on the development of self-study training materials to aid in the process.

It may be in the interest of individual companies to transfer individuals from their defense divisions into their commercial divisions instead of hiring new people to fill commercial positions, since recruitment costs are high. It may also be in their interest to diversify and expand into commercial activities and to make use of defense engineering talents, particularly in the innovative aspects of new product development. Diversification often requires large investments in R&D unless it is done by acquisition, and a primary source of R&D talents is the defense sector. Defense engineers may also bring to commercial industry expertise in program management, PERT, and similar techniques that will improve commercial operations. Companies should be aware of the advantages accruing from these specialized skills and take their availability into account in planning commercial activities. In budgeting, companies should recognize the probable need to supply funds for retraining and reorienting defense engineers who have transferred. There will probably be additional costs even if such activities are carried out primarily on the job, since engineers will not be fully productive in the early stages of their commercial careers. Additional funding of R&D functions might also be considered by commercially oriented companies as a means of using defense engineering skills. Initial cost might be a problem, but in many areas there should be a high probability of long range payoff.

Most of the managers who were interviewed during the course of the study feel that no part should be taken by government at any level that would bring about government involvement in the internal affairs of their companies. This would include the sponsoring of in-plant training and the like. Some managers did, however, suggest that government fiscal policy, such as tax write-off provisions with respect to the R&D activities, might be used to ease the economic burden that would be imposed on industry in its attempts to absorb large numbers of defense engineers. The actual funding of R&D activities in areas of public concern such as air and water polution, transportation, and the like has been undertaken under government auspices, but the size and scope of such efforts might usefully be increased substantially if the talents of defense engineers were available as a result of defense cutbacks.

Appendix A

QUESTIONNAIRE AND INTERVIEW GUIDE

Budget Bureau No. 102-6601
Approval Expires August 31, 1967

A Study of the Transferability of Engineers

The United States Arms Control and Disarmament Agency (USACDA) has asked Stanford Research Institute to conduct a study that will help define the problems that might be connected with the transfer of engineers from defense work to commercial work on a large-scale basis, and that will suggest solutions to such problems. Your assistance is needed in this important project. For the purposes of this study, the following definitions of terms are used:

- "Defense work" is work primarily related to end-products contracted for and sold to the U.S. Army, Navy, Air Force, or the military services of allied countries (whether under prime contracts or sub-contracts);
- "Commercial work" is work primarily related to end-products for sale to consumers (individuals or companies) in the private sector of the economy;
- "All other work" includes non-defense work for other federal agencies such as NASA or the AEC, work for regional, state, local, or other government agencies, and any other work not covered by the two terms above.

While it is recognized that, in the future, many engineers now in defense work may well be able to transfer to non-defense work for various federal, state, and local agencies, it should be borne in mind that this particular study is focused upon possible problems in the transferability of engineers from defense to commercial work, as these terms are defined above. Please keep these definitions in mind throughout your participation in the study.

In order to accomplish this study, we are asking a sample of engineers and managers of engineering activities in a variety of companies and work contexts to complete the attached questionnaire. Experience with the questionnaire indicates that it takes about twenty minutes to complete, on the average. (Most of the questions are of the check-list type, with some spaces for brief written explanations of answers). Of course, all individual answers will be strictly anonymous. Only research personnel working on this project will have access to individual questionnaires, and the questionnaire responses will be reported mainly in the form of statistical summaries, although representative comments on individual questions may also be cited, but in a form that retains anonymity. Those answering the questionnaire will include a broad sample of engineers both in defense work and in commercial work (some of whom will have had previous experience in one or the other of these kinds of work) in a variety of organizations across the country.

Your name has been selected by a random sampling method to participate in this study. Your cooperation in answering the questions in the attached questionnaire will be greatly appreciated. It is anticipated that the results of this study will be very helpful to government agencies, professional groups of engineers, companies that employ engineers, and schools of engineering in assisting engineers to adjust to possible changes in the scope or character of engineering employment.

Carl Rittenhouse
Project Director
Technology Management Programs
Stanford Research Institute
Menlo Park, California

ACDA/E-110

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

1. Please answer each question. Check the one most appropriate answer on each question. Only one answer on each question can be handled by the data tabulating system.

2. Disregard the numbers alongside the spaces to be checked. They are for use in tabulating the answers.

3. Throughout the questionnaire, please use the definitions of "defense work" and "commercial work" given previously.

4. Please do not sign your name to the questionnaire; all answers are to be anonymous.

5. Please do not discuss items on the questionnaire with co-workers, friends, family members, etc., while filling out the questionnaire; please make the answers your own.

6. You may fill out this questionnaire outside working hours if it is more convenient to your work schedule to do so. In any case, however, it will be greatly appreciated if you could return this questionnaire by mailing it in the attached self-addressed envelope within the next few days so that the deadlines of the study may be met.

Thank you very much for your cooperation in this important study.

I. PRESENT WORK ACTIVITIES AND ATTITUDES

1. Which of the following best describes the specialty in which you are now working (regardless of your earlier training or college degree field)? (check one)

6-0 ___ aeronautical or astronautical engineering
1 ___ civil engineering
2 ___ electrical engineering
3 ___ electronic engineering
4 ___ industrial engineering, operations research, or human factors
5 ___ mechanical engineering
6 ___ metallurgical engineering or metallurgy
7 ___ other engineering; specify: ____________
8 ___ other discipline; specify: ____________

2. Which of the following best describes the work function in which you are mainly engaged at present? (check one)

7-0 ___ research
1 ___ systems analysis and/or design
2 ___ component and/or hardware product design
3 ___ engineering testing
4 ___ technical support (e.g., procurement, liaison, etc.)
5 ___ manufacturing processes design
6 ___ quality assurance, quality control, and/or reliability engineering
7 ___ customer service, sales, and/or customer training
8 ___ other; specify: ____________

3. At present, would you mainly describe your own work as "defense work" or "commercial work"? (check one)

8-1 ___ defense work
2 ___ commercial work
3 ___ non-defense government work
4 ___ other; describe: ____________
____

4. In your opinion, how does commercial work compare to defense work among engineers? (check one)

9-1 ___ commercial work is likely to be much more interesting and challenging than defense work
2 ___ commercial work tends to be somewhat more interesting and challenging
3 ___ commercial work and defense work are about the same in interest and challenge
4 ___ defense work tends to be somewhat more interesting and challenging
5 ___ defense work is likely to be much more interesting and challenging
6 ___ I don't know
Briefly explain reason for answer: ____________
____
____
____

5. If you are now employed in defense work, and if there were jobs open at present in commercial engineering activities in another part of your employing organization, how easy do you think it would be for you now to transfer into such a job (taking into account your work experience, education, age, etc.)? (check one)

10-1 ___ extremely easy
2 ___ pretty easy
3 ___ so-so
4 ___ not very easy
5 ___ practically impossible
9 ___ (am now employed in commercial work or non-defense work) Please write a few words to explain your answer: ___

6. Please indicate whether or not you presently have supervisory or managerial responsibilities for the work of other (professional level) engineers. (check one)

11-0 ___ presently have no supervisory responsibilities for the work of other engineers
1 ___ presently supervise from one through four engineers on an engineering project assignment
2 ___ presently supervise five or more engineers on an engineering project assignment
3 ___ presently supervise from one through four engineers in a "permanent" engineering group, section, or department
4 ___ presently supervise five or more engineers in a "permanent" engineering group, section, or department

7. Which of the following best describes the extent to which the manager of your immediate work group usually directs your engineering work? (check one)

12-1 ___ he closely directs my work
2 ___ we occasionally consult on my work
3 ___ we rarely discuss my work

8. In the next ten years or so, do you hope to (check one)

13-1 ___ go into (or remain in) a supervisory or managerial position in engineering or related work
2 ___ go into (or remain in) a non-supervisory engineering job in your present specialty field of engineering
3 ___ go into a non-supervisory engineering job in another specialty field of engineering; (write in name of specialty field)
4 ___ go into some other line of work; (describe) ___

9. Overall, do you feel that management in your employing organization has given your work the recognition you think it deserves? (check one)

14-1 ___ yes, definitely
2 ___ yes, I think so
3 ___ no, I don't think so
4 ___ no, definitely not

10. As you see it now, what do you hope you will be doing about ten years from now? (Read all the answers carefully, then check the one answer that applies best to you.)

15-1 ___ working in your present employing organization in defense work
2 ___ working in your present employing organization in commercial work
3 ___ working in your present employing organization in non-defense work for government agencies
4 ___ working in a different organization in defense work
5 ___ working in a different organization in commercial work
6 ___ working in a different organization in non-defense work for government agencies
7 ___ working in business for self
8 ___ retired or not working for pay

11. If you had to choose, would you say you are more identified with (1) your employing organization or (2) your engineering profession? (check one)

16-1 ___ my present employing organization
2 ___ my engineering profession

12. Taking everything into account, how satisfied or dissatisfied are you with your present job in your employing organization? (check one)

17-1 ___ very satisfied
2 ___ satisfied
3 ___ somewhat satisfied and somewhat dissatisfied
4 ___ dissatisfied
5 ___ very dissatisfied

II. PAST WORK ACTIVITIES AND ATTITUDES

1. About how many years of total employment experience have you had in defense engineering work? (check one)

18-9 ___ none
0 ___ less than one year's experience
1 ___ one year
2 ___ two years
3 ___ three years
4 ___ four years
5 ___ five through nine years
6 ___ ten through fourteen years
7 ___ fifteen through nineteen years
8 ___ twenty years or more

2. About how many years of total employment experience have you had in commercial engineering work? (check one)

19-9 ___ none
0 ___ less than one year's experience
1 ___ one year
2 ___ two years
3 ___ three years
4 ___ four years
5 ___ five through nine years
6 ___ ten through fourteen years
7 ___ fifteen through nineteen years
8 ___ twenty years or more

3. How many years of total employment experience have you had in engineering work, considering defense, commercial, and non-defense government work added together? (check one)

20-1 ___ less than five years' total employment work experience
2 ___ five through nine years
3 ___ ten through fourteen years
4 ___ fifteen through nineteen years
5 ___ twenty years or more

4. How many years have you had with your present employing organization in defense engineering work? (check one)

21-9 ___ none
0 ___ less than one year's experience
1 ___ one year
2 ___ two years
3 ___ three years
4 ___ four years
5 ___ five through nine years
6 ___ ten through fourteen years
7 ___ fifteen through nineteen years
8 ___ twenty years or more

5. How many years have you had with your present employing organization in commercial engineering work? (check one)

22-9 ___ none
0 ___ less than one year's experience
1 ___ one year
2 ___ two years
3 ___ three years
4 ___ four years
5 ___ five through nine years
6 ___ ten through fourteen years
7 ___ fifteen through nineteen years
8 ___ twenty years or more

6. Altogether, in how many different employing organizations have you been employed in the past five years? (check one)

23-1 ___ only one
2 ___ two
3 ___ three
4 ___ four
5 ___ five
6 ___ six or more

7. Please indicate whether or not you have had any supervisory or managerial responsibilities for engineers in defense engineering work before coming into your present job. (check one)

24-0 ___ no, have not had any previous supervisory responsibilities in defense engineering work
1 ___ yes, have previously supervised engineers on defense engineering project assignments
2 ___ yes, have previously supervised engineers in a "permanent" defense engineering group, section, or department
3 ___ yes, have previously supervised engineers both on defense projects and in "permanent" defense engineering groups

8. Please indicate whether or not you have had any supervisory or managerial responsibilities for engineers in commercial engineering work before coming into your present job. (check one)

25-0 ___ no, have not had any previous supervisory responsibilities in commercial engineering work
1 ___ yes, have previously supervised engineers in commercial engineering project assignments
2 ___ yes, have previously supervised engineers in a "permanent" commercial engineering group, section, or department
3 ___ yes, have previously supervised engineers both on commercial projects and in "permanent" commercial engineering groups

9. If you have had any previous experience in defense work, which of the following best describes the specialty field in which you were last working (in defense work)? (check one)

26-0 ___ aeronautical or astronautical engineering
1 ___ civil engineering
2 ___ electrical engineering
3 ___ electronic engineering
4 ___ industrial engineering, operations research, or human factors
5 ___ mechanical engineering
6 ___ metallurgical engineering or metallurgy
7 ___ other engineering; specify: ____________
8 ___ other discipline; specify: ____________
9 ___ have had no previous experience in defense work

10. If you have had any previous experience in commercial work, which of the following best describes the specialty field in which you were last working (in commercial work)? (check one)

27-0 ___ aeronautical or astronautical engineering
1 ___ civil engineering
2 ___ electrical engineering
3 ___ electronic engineering
4 ___ industrial engineering, operations research, or human factors
5 ___ mechanical engineering
6 ___ metallurgical engineering or metallurgy
7 ___ other engineering: specify: ___
8 ___ other discipline; specify: ___
9 ___ have had no previous experience in commercial work

11. If you have had any previous experience in defense work, which of the following best describes the work function to which you were assigned in your last defense job? (check one)

28-0 ___ research
1 ___ systems analysis and/or design
2 ___ component and/or hardware product design
3 ___ engineering testing
4 ___ technical support (e.g., procurement, liaison, etc.)
5 ___ manufacturing processes design
6 ___ quality assurance, quality control, and/or reliability engineering
7 ___ customer service, sales, and/or customer training
8 ___ other; specify: ___
9 ___ have had no previous experience in defense work

12. If you have had any previous experience in commercial work, which of the following best describes the work function to which you were assigned in your last commercial job? (check one)

29-0 ___ research
1 ___ systems analysis and/or design
2 ___ component and/or hardware product design
3 ___ engineering testing
4 ___ technical support (e.g., procurement, liaison, etc.)
5 ___ manufacturing processes design
6 ___ quality assurance, quality control, and/or reliability engineering
7 ___ customer service, sales, and/or customer training
8 ___ other; specify: ___
9 ___ have had no previous experience in commercial work

13. If you have had any previous experience in defense work, please indicate the extent to which your last manager in defense work directed your engineering activities: (check one)

30-1 ___ he closely directed my work
2 ___ we occasionally consulted on my work
3 ___ we rarely discussed my work
9 ___ have had no previous experience in defense work

14. If you have had any previous experience in commercial work, please indicate the extent to which your last manager in commercial work directed your engineering activities: (check one)

31-1 ___ he closely directed my work
2 ___ we occasionally consulted on my work
3 ___ we rarely discussed my work
9 ___ have had no previous experience in commercial work

15. In your opinion, which kind of work generally requires the closest kind of supervision? (check one)

32-1 ___ defense work
2 ___ commercial work
3 ___ both about equal
4 ___ I don't know

16. If you have ever left a defense engineering job in order to take a commercial engineering job, please indicate in a few words why you made this change:

______
______
______

33-___ (do not write here)

17. How easy was it for you to make this change from defense to commercial engineering work? (check one)

34-1 ___ extremely easy
2 ___ pretty easy
3 ___ so-so
4 ___ not very easy
5 ___ extremely difficult
9 ___ (have never transferred from defense to commercial work)

Please write a few words to explain why this change was easy or difficult:

______
______
______
______
______
______

18. Was this change from defense to commercial work any more difficult than the changes you may have made in transferring from one defense job to another, or from one commercial job to another? (check one)

35-1 ___ yes, much more difficult
2 ___ yes, somewhat more difficult
3 ___ about the same
4 ___ no, not as difficult
5 ___ no, much less difficult
6 ___ cannot answer because I have not made transfers both within defense or commercial work and between defense and commercial work

Please explain why this transfer from defense to commercial work was easier or more difficult than other transfers:

___

___

___

III. BACKGROUND AND EDUCATIONAL EXPERIENCE

1. Are you: (check one)

36-1 ___ male
2 ___ female

2. What is your age? (check one)

37-0 ___ 24 years of age or less
1 ___ 25 through 29 years
2 ___ 30 through 34 years
3 ___ 35 through 39 years
4 ___ 40 through 44 years
5 ___ 45 through 49 years
6 ___ 50 through 54 years
7 ___ 55 through 59 years
8 ___ 60 years or over

3. At present, are you: (check one)

38-1 ___ married
2 ___ single (never married)
3 ___ divorced
4 ___ legally separated from spouse
5 ___ widowed

4. Not counting yourself, how many other persons are dependent upon your income for one-half or more of their support? (check one)

39-0 ___ none
1 ___ one person
2 ___ two
3 ___ three
4 ___ four
5 ___ five
6 ___ six
7 ___ seven
8 ___ eight or more

5. Please list below any professional engineering societies or associations to which you belong at the present time:

___

___

40- ___ (do not write here)

6. During the past 12 months, how many professional engineering meetings, conferences, or symposia have you attended outside your city area? (check one)

41-0 ___ none during the past 12 months
1 ___ one
2 ___ two
3 ___ three
4 ___ four
5 ___ five or more

7. Please list below any union-type organizations for professional engineers to which you belong at the present time:

___

___

42- ___ (do not write here)

8. What is your present gross annual salary (before taxes and all deductions)? (check one)

43-0 ___ under $7,000 per annum
1 ___ $7,000 to $8,999
2 ___ $9,000 to $10,999
3 ___ $11,000 to $12,999
4 ___ $13,000 to $14,999
5 ___ $15,000 to $16,999
6 ___ $17,000 to $18,999
7 ___ $19,000 to $21,999
8 ___ $22,000 and above

9. Your highest degree: (check one)

44-1 ___ doctor's
2 ___ master's
3 ___ bachelor's
4 ___ less than bachelor's
5 ___ other graduate degree; specify: ___

10. In which one of the following specialty fields did you receive your highest degree? (check one)

45-0 ___ aeronautical or astronautical engineering
1 ___ civil engineering
2 ___ electrical engineering
3 ___ electronic engineering
4 ___ industrial engineering, operations research, or human factors
5 ___ mechanical engineering
6 ___ metallurgical engineering or metallurgy
7 ___ other engineering; specify: ___
8 ___ other discipline; specify: ___

11. In what year was your highest degree conferred? (check one)

46-0 ___ 1966
1 ___ 1965
2 ___ 1964 or 1963
3 ___ 1962 or 1961
4 ___ 1956 through 1960
5 ___ 1951 through 1955
6 ___ 1946 through 1950
7 ___ 1941 through 1945
8 ___ 1940 or before

12. From what college or university did you receive your highest degree? (please write it in here)

____

47- ___ (do not write here)

13. Are you certified or licensed for engineering work under the laws of any of the fifty states? (check one)

48-1 ___ yes, I am licensed or certified in one or more states
2 ___ no, I am not

14. Please indicate below whether or not you have ever had any courses in business administration or business management subjects given under the auspices of a college or university. (check one)

49-0 ___ no, have not had any such courses
1 ___ yes, have had one or more business administration courses given under the auspices of a college or university before receiving my last engineering degree
2 ___ yes, have had such courses after receiving my last engineering degree
3 ___ yes, have had one or more such courses both before and after receiving my last engineering degree

15. Please indicate below whether or not you have ever had any courses in industrial engineering subjects given under the auspices of a college or university. (check one)

50-0 ___ no, have not had any such courses
1 ___ yes, have had one or more industrial engineering courses given under the auspices of a college or university before receiving my last engineering degree
2 ___ yes, have had such courses after receiving my last engineering degree
3 ___ yes, have had one or more such courses both before and after receiving my last engineering degree

16. Please indicate below whether or not you have taken any training courses given by your present employing organization (exclude college or university-sponsored courses); (check one)

51-0 ___ no, have not taken any such training courses
1 ___ yes, have had more than 20 hours of training in courses given by my present employing organization; please list courses ____________
____
____
____

2 ___ yes, but have had less than 20 hours of training in courses given by my present employing organization; please list courses ____________
____
____
____

17. Please indicate below whether or not you have taken any training courses given by your past employers (exclude college or university-sponsored courses): (check one)

52-0 ___ no, have not taken any such training courses
1 ___ yes, have had more than 20 hours of training in courses given by a past employing organization; please list courses ____________
____
____
____

2 ___ yes, but have had less than 20 hours of training in courses given by a past employing organization; please list courses ____________
____
____
____
____

18. Please list the kinds of training courses or training programs that you feel would be necessary in preparing an engineer with your kind of background to transfer from defense to commercial work:

____
____
____
____
____

53- ___ (do not write here)

IV. CHECK LIST

Suppose there were an increased demand for engineers in commercial jobs with reasonable salary scales. Following are some items that have been suggested as possible problem areas under such conditions. We would like to know how much you think each item would be a problem for defense engineers transferring from defense to commercial work, in terms of your own experience and judgment on the matter. (Even if you feel you do not definitely know about the item, please try to indicate your opinion on it).

1. "Commercial work might require engineers in different specialties than is required in defense work" (check one)

54-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

2. "Commercial work might require more engineers who are broad generalists rather than narrow specialists, in comparison to what is required in defense work" (check one)

55-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

3. "Commercial work might require a more careful consideration of cost factors than is the case in defense work" (check one)

56-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

4. "Commercial work might require less emphasis upon product reliability than is the case in defense work" (check one)

57-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

5. "Commercial work might require customer relations and 'tech rep' work on the part of more engineers than is the case in defense work" (check one)

58-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

6. "Commercial work might require more knowledge of a specific product line than is the case in defense work" (check one)

59-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

7. "Many commercial managers might believe that defense engineers are not well suited to commercial work" (check one)

60-1 ___ definitely a problem
2 ___ quite likely to be a problem
3 ___ possibly a problem
4 ___ not likely to be a problem
5 ___ definitely not a problem
6 ___ don't know whether a problem or not

8. Would you now please check the one item that, in your opinion, would constitute the most serious problem in the large scale transfer of engineers from defense to commercial work: (check one)

61-1 ___ requirements for engineers in different specialties
2 ___ requirements for more engineers who are broad generalists
3 ___ more emphasis upon cost factors in engineering work
4 ___ less emphasis upon reliability considerations in engineering work
5 ___ requirements for more engineers in customer relations work
6 ___ requirements for knowledge of a specific product line
7 ___ managers' beliefs that defense engineers are not well suited to commercial work

9. We would appreciate any additional comments you have to make on serious problems or obstacles to be overcome in order to have a successful large-scale transfer of engineers from defense work to commercial work. What could be done to overcome these problems? Please write any comments here:

____

____

____

____

62-___

Date: ____________

INTERVIEW GUIDE

Time: ____________

Place: ____________

(To be used in personal interviews with managers after they have completed the questionnaire entitled "A Study of the Transferability of Engineers.")

Name: ____________

Position and Level: ____________

Company: ____________

Division or Department: ____________

Address: ____________

____

Introduction

Introduce self. Make sure that the purpose of the study is understood by the respondent. Give further explanation if necessary. Thank respondent for completing the questionnaire.

Questions

1. a. Are there any comments that you would like to add now to what you wrote in the questionnaire?

b. Specifically, what do you think are the main problems in making a successful large scale transfer of engineers from defense to commercial work? (list here)

c. Could you rank these problems in (1) degree of seriousness for the engineers involved, and (2) extent of the problem -- i.e., number of engineers that would be affected?

d. In your experience or opinion, does commercial engineering involve significantly different labor market conditions (e.g., lower grades for entry, more career commitment to an employer, etc.)? If so, how does this affect the transferability of defense engineers?

e. In what kind of work functions do you think defense engineers might be best placed?

2. a. What experience has your company (or your division or department) had in transferring engineers from defense to commercial work?

b. Did this transfer involve only a few individuals, or did it involve a shift of an entire group, department, or division?

d. Were key engineering personnel shifted first?

d. Did it involve a geographic shift?

e. Did the shift involve any major changes in:

(1) salary scales?

(2) employee benefits?

(3) engineering specialty requirements?

(4) R&D work function assignments?

(5) similar or related matters

f. Did the shift involve any changes in educational or training requirements?

g. How were any changes in educational or training requirements met?

(1) Amount and types of training involved.

(2) Number and kinds of engineers retrained.

(3) Organizations and/or kinds of instructors who did the training.

(4) Costs of training to the employer; the individual; others.

h. In your opinion, how effective was the retraining? Were any measures made of this?

i. What did you, or your company, learn from this experience? Would you do the same things, or different things, if you had it to do over again? Do you think that what you learned would apply to a situation in which larger numbers of engineers might have to be transferred from defense to commercial work? Why, or why not?

3. a. What do you think could be done to solve the problems of transfer?

b. Do you think that training could make any contribution to this?

c. More specifically, what kinds of training courses or training programs could be given to help engineers transfer from defense to commercial work? (E.g., orientation, engineering content, business environment, course work vs. O.J.T.).

d. How much of each kind of training should be given, in your opinion, i.e., number of hours of each kind of training?

e. What organizations (e.g., colleges or universities, companies, other organizations) do you think would be best prepared to give each kind of training?

f. What role do you think federal government agencies could play in this training?

4. a. In view of your experiences, what role do you think attitude factors (in contrast to specific skill or knowledge factors) play in supporting or hindering the transferability of engineers from defense to commercial work?

b. Do you think it is true that in commercial work, engineers must be (1) more cost conscious, (2) less concerned with product reliability, (3) more interested in and knowledgeable about the company's product line, (4) more concerned with customer relations, (5) etc.?

c. Do you think that most engineers in defense work look upon commercial work as being any less interesting and challenging, or any more interesting and challenging, than defense work? Why?

d. If your answer is "yes" to any of the above, what contributions could training make to changing attitudes in a way that would aid transfer? (Attempt to obtain as specific information as possible on types, amount, costs, organizational context, etc., of training).

5. Can you think of any additional comments to make regarding problems in transferring engineers from defense to commercial work, and regarding how these transfers can be made most effectively and successfully?

Conclusion

Thank you again for your comments. They have indeed been valuable and useful to our study. We will plan to send a copy of the report on this study to your company, so that you can see the conclusions after our analysis has been completed.

Appendix B

SUPPORTING DATA

TABLE 1

HIGHEST DEGREE BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=480)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=424)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2019)
Doctor's	3%	3%	4%	2%	5%	3%
Master's	17	19	24	30	28	24
Bachelor's	66	69	58	62	57	62
Less than a Bachelor's	13	6	13	6	7	10
Other Graduate Degrees	1	3	1	0	2	1

TABLE 2 SPECIALTY IN WHICH NOW WORKING BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=668)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2024)
Aeronautical or Astronautical Engineering	16%	5%	14%	12%	17%	14%
Civil Engineering	1	1	1	0	1	1
Electrical Engineering	6	8	5	7	4	6
Electronic Engineering	29	27	33	45	34	34
Industrial Engineering, Operations Research, or Human Factors	2	1	5	4	4	4
Mechanical Engineering	23	29	17	13	21	20
Metallurgical Engineering	1	2	2	1	2	2
Other Engineering	18	24	17	9	12	16
Other Disciplines	3	3	6	7	5	5

TABLE 3

EXISTENCE OF DIFFERENT SPECIALTIES IN COMMERCIAL WORK AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=481)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2020)
Definitely a Problem	8%	7%	9%	7%	5%	8%
Quite Likely to be a Problem	17	15	18	20	23	18
Possibly a Problem	36	34	35	31	34	34
Not Likely to be a Problem	34	37	31	35	30	33
Definitely not a Problem	5	3	5	5	6	5
Don't Know	0	4	2	2	1	1

TABLE 4

NEED FOR MORE GENERALISTS IN COMMERCIAL WORK AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=483)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2022)
Definitely a Problem	10%	11%	10%	5%	10%	9%
Quite Likely to be a Problem	24	23	17	18	19	20
Possibly a Problem	31	37	31	23	28	29
Not Likely to be a Problem	28	22	32	40	35	32
Definitely Not a Problem	6	4	9	11	7	8
Don't Know	1	4	2	2	1	2

TABLE 5 COURSES NEEDED TO TRANSFER FROM DEFENSE TO COMMERCIAL BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=371)	NO PREVIOUS DEFENSE (N=107)	PREVIOUS COMMERCIAL (N=532)	NO PREVIOUS COMMERCIAL (N=344)	NON-DEFENSE GOVERNMENT (N=190)	TOTAL (N=1544)
None or On-the-Job Training	41%	31%	41%	27%	31%	36%
Business Administration, Management, Engineering Management, P.E.R.T., Customer Relations, etc.	6	4	10	11	11	9
Cost Accounting, Analysis or Effectiveness, Economics, etc.	12	9	10	13	12	11
Value Engineering	3	3	3	4	5	3
Marketing Analysis	2	2	4	3	3	3
Manufacturing or Production, or Industrial Engineering, Consumer or Product Oriented Courses	15	7	12	19	17	14
Specific Engineering Related Courses, Updating, etc.	9	11	9	6	10	8
Mathematics, Physics, Statistics	2	0	1	1	2	1
Miscellaneous	6	5	7	7	4	6
Don't Know or Not Applicable	5	29	4	10	7	7

TABLE 6 WORK FUNCTION IN WHICH NOW ENGAGED BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=668)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2023)
Research	7%	12%	8%	8%	12%	9%
Systems Analysis and/or Design	30	26	38	45	44	37
Component and/or Hardware Product Design	30	25	21	24	20	24
Engineering Testing	6	8	6	6	8	6
Technical Support (e.g., Procurement, Liaison, etc.)	7	7	6	5	6	6
Manufacturing Process Design	3	5	5	2	1	3
Quality Assurance, Control and/or Reliability Engineering	5	9	7	3	3	5
Customer Service, Sales, and/or Customer Training	2	2	2	1	0	2
Other	8	6	7	6	7	7

TABLE 7

EASE OF DEFENSE - COMMERCIAL TRANSFERS COMPARED TO OTHER TRANSFERS BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=336)	NO PREVIOUS DEFENSE	PREVIOUS COMMERCIAL (N=200)	NO PREVIOUS COMMERCIAL	NON-DEFENSE GOVERNMENT (N=56)	TOTAL (N=599)
Yes, Much More Difficult	3%	N.A.	2%	N.A.	7%	3%
Yes, Somewhat More Difficult	9	N.A.	9	N.A.	7	9
About the Same	74	N.A.	72	N.A.	70	72
No, Not As Difficult	7	N.A.	12	N.A.	9	9
No, Much Less Difficult	7	N.A.	6	N.A.	7	7

TABLE 8

MORE CONSIDERATION OF COST FACTORS IN COMMERCIAL WORK AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=666)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2021)
Definitely a Problem	39%	32%	32%	30%	32%	33%
Quite Likely to be a Problem	29	31	25	27	32	28
Possibly a Problem	20	19	19	21	16	19
Not Likely to be a Problem	9	13	18	14	15	14
Definitely not a Problem	3	3	7	6	4	5
Don't Know	0	2	0	1	1	1

TABLE 9

LESS EMPHASIS ON RELIABILITY IN COMMERCIAL WORK AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2022)
Definitely a Problem	6%	3%	8%	8%	5%	7%
Quite Likely to be a Problem	8	10	14	18	14	13
Possibly a Problem	22	24	21	25	26	23
Not Likely to be a Problem	38	45	40	36	42	39
Definitely not a Problem	24	16	15	12	11	16
Don't Know	2	3	2	1	1	2

TABLE 10

INTEREST AND CHALLENGE OF DEFENSE OR COMMERCIAL WORK AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=480)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=666)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2019)
Commercial Much More Interesting and Challenging	15%	18%	5%	4%	5%	9%
Commercial Somewhat More Interesting and Challenging	20	12	7	6	6	10
Commercial and Defense About the Same	37	26	33	19	32	30
Defense Somewhat More Interesting and Challenging	15	8	23	23	22	19
Defense Much More Interesting and Challenging	8	5	26	29	17	19
Don't Know	6	32	6	20	18	13

TABLE 11

HOPED-FOR EMPLOYING ORGANIZATION AND TYPE OF WORK IN TEN YEARS BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=483)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=664)	NO PREVIOUS COMMERCIAL (N=424)	NON-DEFENSE GOVERNMENT (N=251)	TOTAL (N=2015)
Present Organization in Defense Work	2%	0%	34%	40%	5%	21%
Present Organization in Commercial Work	63	64	15	8	8	29
Present Organization in Non-defense Government Work	1	1	11	16	48	13
Different Organization in Defense Work	1	1	6	12	1	5
Different Organization in Commercial Work	17	22	10	9	8	12
Different Organization in Non-defense Government Work	1	1	3	4	12	3
Business for Self	9	9	15	10	13	12
Retired or Not Working for Pay	7	2	6	3	5	5

TABLE 12 HOPED-FOR SPECIALTY AND SUPERVISORY ROLE IN TEN YEARS BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=481)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=664)	NO PREVIOUS COMMERCIAL (N=423)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2015)
Supervisory or Managerial Position in Engineering or Related Work	79%	82%	72%	75%	73%	75%
Non-Supervisory Engineering Job in Present Engineering Specialty	14	11	16	16	18	15
Non-Supervisory Engineering Job in Another Engineering Specialty Field	1	2	1	2	1	1
Some Other Line of Work	7	4	11	7	8	8

TABLE 13

ASSUMED MANAGERS ATTITUDES TOWARD DEFENSE ENGINEERS AS A TRANSFER PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=668)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2023)
Definitely a Problem	11%	5%	18%	14%	16%	14%
Quite Likely to be a Problem	19	13	24	26	26	22
Possibly a Problem	31	30	34	28	31	31
Not Likely to be a Problem	28	34	17	17	17	21
Definitely not a Problem	6	9	3	7	3	5
Don't Know	4	9	5	9	6	6

TABLE 14

ENGINEERS ESTIMATES OF MOST SERIOUS TRANSFERABILITY PROBLEM BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=472)	NO PREVIOUS DEFENSE (N=191)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=424)	NON-DEFENSE GOVERNMENT (N=250)	TOTAL (N=2004)
Different Specialties	13%	20%	18%	18%	15%	17%
Need for Generalists	21	24	11	9	18	15
Cost Factors	39	38	32	37	34	36
Reliability Considerations	2	0	4	3	2	3
More Need for Customer Relations	4	4	3	4	1	3
Knowledge of Specific Product Line	6	6	9	7	9	7
Managers' Beliefs	15	8	23	23	21	19

TABLE 15 SPECIALTY IN LAST PREVIOUS DEFENSE EMPLOYMENT BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=187)	PREVIOUS COMMERCIAL (N=657)	NO PREVIOUS COMMERCIAL (N=421)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2001)
Aeronautical or Astronautical Engineering	15%	N.A.	16%	12%	17%	14%
Civil Engineering	1	N.A.	0	0	1	0
Electrical Engineering	5	N.A.	5	6	5	5
Electronic Engineering	31	N.A.	29	34	31	28
Industrial Engineering, Operations Research, or Human Factors	2	N.A.	4	2	2	2
Mechanical Engineering	24	N.A.	15	9	15	14
Metallurgical Engineering	1	N.A.	1	0	2	1
Other Engineering	14	N.A.	8	7	6	8
Other Disciplines	2	N.A.	3	5	2	3
No Previous Defense Experience	N.A.	N.A.	21	25	19	25

TABLE 16 FUNCTION IN LAST PREVIOUS DEFENSE EMPLOYMENT BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=185)	PREVIOUS COMMERCIAL (N=655)	NO PREVIOUS COMMERCIAL (N=421)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=1996)
Research	7%	N.A.	7%	9%	7%	7%
Systems Analysis and/or Design	27	N.A.	29	33	34	27
Component and/or Hardware Product Design	29	N.A.	20	17	22	20
Engineering Testing	8	N.A.	8	5	7	7
Technical Support (e.g., Procurement, Liaison, etc.)	6	N.A.	3	3	4	4
Maufacturing Process Design	5	N.A.	4	1	2	3
Quality Assurance Control and/or Reliability Engineering	4	N.A.	4	3	3	3
Customer Service, Sales, and/or Customer Training	2	N.A.	1	1	1	1
Other	5	N.A.	4	3	2	4
No Previous Defense Experience	6	N.A.	20	25	20	25

TABLE 17 LEVEL OF PRESENT SUPERVISORY ACTIVITY BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N-426)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2023)
No Supervisory Responsibility	43%	60%	40%	44%	45%	44%
Supervise 1-4 Engineers on Project or Assignment	18	16	18	20	24	19
Supervise 5 or more Engineers on Project or Assignment	6	0	10	8	9	8
Supervise 1-4 in "Permanent" Engineering Group, Section or Department	9	11	7	9	8	8
Supervise 5 or more in "Permanent" Engineering Group, Section or Department	23	13	24	19	15	21

TABLE 18

SUPERVISORY RESPONSIBILITY IN DEFENSE WORK BEFORE PRESENT JOB BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=481)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2020)
No Previous Supervisory Responsibility in Defense Work	59%	N.A.	52%	66%	59%	62%
Yes, Supervisory Responsibility in Defense Project Assignment	22	N.A.	21	18	25	19
Yes, Supervisory Responsiblity in "Permanent" Defense Group, Section or Department	11	N.A.	11	8	6	9
Both Project and "Permanent" Group	8	N.A.	15	8	9	10

TABLE 19 SUPERVISION IN IMMEDIATE WORK GROUP BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=478)	NO PREVIOUS DEFENSE (N=191)	PREVIOUS COMMERCIAL (N=665)	NO PREVIOUS COMMERCIAL (N=425)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2013)
Manager Closely Directs Work	11%	14%	6%	10%	12%	10%
Occasionally Consult on Work	78	78	78	72	72	76
Rarely Discuss Work	11	8	16	19	16	14

TABLE 20

SUPERVISION BY LAST PREVIOUS DEFENSE MANAGER BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=482)	NO PREVIOUS DEFENSE (N=186)	PREVIOUS COMMERCIAL (N=653)	NO PREVIOUS COMMERCIAL (N=417)	NON-DEFENSE GOVERNMENT (N=252)	TOTAL (N=1990)
Manager Closely Directed Work	23%	N.A.	13%	18%	18%	16%
Occasionally Consulted on Work	61	N.A.	57	49	56	51
Rarely Discussed Work	11	N.A.	10	9	7	9
No Previous Defense Experience	5	N.A.	20	25	19	25

TABLE 21

SUPERVISION BY LAST PREVIOUS COMMERCIAL MANAGER BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=478)	NO PREVIOUS DEFENSE (N=193)	PREVIOUS COMMERCIAL (N=663)	NO PREVIOUS COMMERCIAL (N=409)	NON-DEFENSE GOVERNMENT (N=249)	TOTAL (N=1991)
Manager Closely Directed Work	15%	17%	26%	N.A.	16%	16%
Occasionally consulted on Work	54	47	53	N.A.	36	40
Rarely Discussed Work	8	7	11	N.A.	7	7
No Previous Commercial Experience	22	29	10	N.A.	41	36

TABLE 22 IDENTIFICATION WITH PRESENT ORGANIZATION OR ENGINEERING PROFESSION BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=480)	NO PREVIOUS DEFENSE (N=192)	PREVIOUS COMMERCIAL (N=665)	NO PREVIOUS COMMERCIAL (N=426)	NON-DEFENSE GOVERNMENT (N=252)	TOTAL (N=2015)
Present Employing Organization	65%	63%	56%	53%	50%	58%
Engineering Profession	35	37	44	47	50	42

TABLE 23

AGE BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=481)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=667)	NO PREVIOUS COMMERCIAL (N=424)	NON-DEFENSE GOVERNMENT (N=254)	TOTAL (N=2020)
24 Years or Less	1%	10%	2%	7%	2%	3%
25 through 29 Years	10	30	9	18	13	14
30 through 34 Years	26	23	15	26	26	22
35 through 39 Years	20	22	22	24	25	22
40 through 44 Years	21	11	24	14	15	19
40 through 49 Years	13	3	17	8	12	12
50 through 54 Years	6	1	7	2	5	5
55 through 59 Years	2	1	3	1	2	2
60 Years or Over	1	0	2	0	0	1

TABLE 24

GROSS ANNUAL SALARY BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=479)	NO PREVIOUS DEFENSE (N=192)	PREVIOUS COMMERCIAL (N=666)	NO PREVIOUS COMMERCIAL (N=421)	NON-DEFENSE GOVERNMENT (N=250)	TOTAL (N=2008)
Under $7,000	0%	0%	0%	0%	0%	0%
$7,000 - $8,999	1	10	3	6	2	4
$9,000 - $10,999	11	23	11	14	11	13
$11,000 - $12,999	27	29	18	24	20	22
$13,000 - $14,999	20	22	19	19	24	20
$15,000 - $16,999	14	8	15	14	18	14
$17,000 - $18,999	10	4	14	8	11	10
$19,000 - $21,999	9	2	11	12	8	10
$22,000 and Above	7	1	10	4	6	7

TABLE 25 SPECIALTY FIELD OF HIGHEST DEGREE BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=422)	NO PREVIOUS DEFENSE (N=183)	PREVIOUS COMMERCIAL (N=579)	NO PREVIOUS COMMERCIAL (N=401)	NON-DEFENSE GOVERNMENT (N=236)	TOTAL (N=1821)
Aeronautical or Astronautical Engineering	11%	4%	11%	9%	11%	10%
Civil Engineering	2	1	1	1	2	2
Electrical Engineering	18	21	25	26	16	22
Electronic Engineering	20	15	16	24	22	19
Industrial Engineering, Operations Research, or Human Factors	1	3	3	1	1	2
Mechanical Engineering	30	27	18	16	19	21
Metallurgical Engineering	1	4	2	1	2	2
Other Engineering	6	8	8	3	7	7
Other Disciplines	11	17	15	19	20	16

TABLE 26 SCHOOL FROM WHICH HIGHEST DEGREE RECEIVED BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=478)	NO PREVIOUS DEFENSE (N=189)	PREVIOUS COMMERCIAL (N=659)	NO PREVIOUS COMMERCIAL (N=420)	NON-DEFENSE GOVERNMENT (N=252)	TOTAL (N=1998)
Top 9 Engineering Schools	7%	8%	13%	12%	10%	11%
Universities	50	48	51	63	58	54
Colleges	6	6	5	5	6	6
Engineering, Technical Schools, Military Academies	17	20	13	11	13	14
Junior Colleges and Two-Year Colleges	1	0	0	0	0	0
Miscellaneous	2	2	1	1	2	1
Foreign English Speaking	4	6	2	1	2	3
Other Foreign	1	5	2	0	2	2
All Other	0	0	0	0	0	0
None or No Degree	12	5	14	6	7	10

TABLE 27 PRESENT EMPLOYER COURSES BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=480)	NO PREVIOUS DEFENSE (N=194)	PREVIOUS COMMERCIAL (N=666)	NO PREVIOUS COMMERCIAL (N=424)	NON-DEFENSE GOVERNMENT (N=253)	TOTAL (N=2017)
No Courses by Present Employer	37%	39%	42%	46%	47%	42%
Yes, More than 20 Hours	47	40	45	42	40	44
Yes, but Less than 20 Hours	16	21	13	12	13	14

TABLE 28

PAST EMPLOYER COURSES BY TYPE OF PRESENT EMPLOYMENT

	COMMERCIAL		DEFENSE			
	PREVIOUS DEFENSE (N=468)	NO PREVIOUS DEFENSE (N=191)	PREVIOUS COMMERCIAL (N=650)	NO PREVIOUS COMMERCIAL (N=414)	NON-DEFENSE GOVERNMENT (N=248)	TOTAL (N=1971)
No Courses by Past Employer	67%	71%	69%	78%	69%	70%
Yes, More than 20 Hours	26	19	25	15	23	22
Yes, but Less than 20 Hours	7	9	6	7	8	7

Appendix C

THE VALIDITY OF THE GENERAL CONCLUSIONS

Howard M. Vollmer

Appendix C

THE VALIDITY OF THE GENERAL CONCLUSIONS

Howard M. Vollmer

A large proportion of the findings in this report has been drawn from self-administered questionnaires. An examination was made of the ways and extent to which the experiences and attitudes of engineers employed in defense work differ from the experiences and attitudes of engineers employed in commercial work. An examination was also made of the extent to which engineers in these two different kinds of work see similar or different problems connected with the large scale transfer of engineers from one kind of work to the other. In both cases, the engineers themselves told us what their experiences and attitudes are and what their perceptions of the problems of transfer might be. But one can legitimately ask, how can we be sure that they told us the truth?

Of course, any individual may make responses on a questionnaire that do not accurately reflect his true experiences, attitudes, or opinions--either because of a conscious desire to give answers distorted in a particular direction (for example, a desire to give the kinds of answers that the respondent thinks the investigator would like to hear) or because of an unconscious biasing tendency (for example, a general dislike of one's supervisor that may cause a respondent to give negative responses about all aspects of his job).* But idiosyncratic variations in individual responses are not relevant here. We only need to know whether we can have a reasonable degree of confidence that the collective responses of, say, defense engineers compared with commercial engineers, or nonsupervisory engineers compared with engineering managers, reflect accurately any pertinent similarities or differences among the groups being compared.

Several analytical approaches are available to assess the validity of group responses in the present study. These include:

---

* Questionnaire surveys that are properly designed and conducted can do much to reduce biasing factors. See H. M. Vollmer, "The Uses of Questionnaire Surveys in the Analysis of Individual and Group Factors in Research Organizations," Twentieth National Conference on the Administration of Research, Denver Research Institute, Denver, Colorado, 1967, pp. 7-14.

1. A comparison of the internal consistency of responses on certain key questions in this study. Do the different groups of respondents answer different questions about similar topics in a consistent pattern?

2. A comparison of the external consistency of responses on certain key questions. For example, do nonsupervisory engineers and engineering managers tend to answer questions about similar situations in a consistent way? Or do respondents in other professional categories (e.g., scientists) tend to answer questions about particular situations in ways that support the engineers' answers about these same situations?

The Internal Consistency of Engineers' Responses

A major conclusion of this study was that "a more careful consideration of cost factors" is most often seen as a problem requiring reorientation among engineers transferring from defense work to commercial work. In response to a specific question on this matter, 37 percent of the commercial engineers and 31 percent of the defense engineers indicated that "a more careful consideration of cost factors" is "definitely a problem" in the transfer situation. The responses of the engineers to no other item in the questionnaire indicated as much concern in relation to transfer. Correspondingly, when asked on another question to choose from among seven items the one that constitutes the most serious problem in the large scale transfer of engineers from defense to commercial work, the largest proportions of both commercial and defense engineers (39 and 34 percent, respectively) indicated "more emphasis upon cost factors."

In another part of the questionnaire, the engineers were asked how closely they are supervised in their present work activities. Although the commercial engineers appeared slightly more likely to indicate that they are "closely directed in their work" than was reported among defense engineers (12 percent and 8 percent, respectively), the large majority in both groups said that they "occasionally consult" with their supervisors on their work (78 percent of the commercial engineers and 76 percent of the defense engineers). Then in response to another question, the two groups of engineers consistently replied that defense work and commercial work are "both about equal" in the closeness of supervision required (53 percent of the commercial engineers and 51 percent of the defense engineers). A small minority of commercial and defense engineers (19 and 15 percent, respectively) maintained that defense work required closer supervision, while another minority (11 percent of the commercial engineers and 12 percent of the defense engineers) believed that, vice versa, commercial work requires closer supervision, and the remainder said they didn't know.

In any case, the data were consistent in that they showed no marked or widespread need for closer supervision in either kind of work. There is certainly no suggestion here that differences in closeness of supervision constitute any kind of widespread barrier to transfer. In both situations, engineers are likely to be treated with the degree of autonomy generally considered appropriate for salaried professional personnel. And in both situations, most of the engineers report that they are generally satisfied with their jobs (55 percent of those in commercial and 53 percent of those in defense) and that their work has gotten adequate recognition from management (79 and 77 percent, respectively).

There is also a reasonably close consistency in responses to several questions indicating the extent to which engineers are personally committed to their present employing organization for a career. Sixty-six percent of the commercial engineers and 62 percent of the defense engineers say that they hope to be working in their present organizations about ten years from now. When asked, "If you had to choose, would you say you are more identified with your employing organization or your engineering profession?" Sixty-four percent of the commercial engineers and 54 percent of the defense engineers indicated that they identified themselves more with their employing organization. That the extent of company career identification is somewhat greater among the commercial engineers may be partly a reflection of the fact that most commercial engineers (82 percent) want to stay in commercial engineering in the future, while only 45 percent of the defense engineers say they want to remain in defense engineering. Twenty-two percent of the defense engineers say they want to transfer into commercial engineering, and another 16 percent would like to get into non-defense government work.

In sum, the group answers from several questions corroborate each other to show that there is only a very slight tendency for commercial engineers to be more likely to be satisfied with their present jobs in general and to be committed to their present companies for a working career, even though there is a definite desire among a sizable number of defense engineers to get out of the defense business. Also, the group answers from several questions support the main conclusion that requirement for a more careful consideration of cost factors is the most marked difference felt by engineers between defense and commercial work--a difference that must be understood by those making the transfer.

However, it is significant that the majority of engineers made responses indicating confidence in the transfer situation, regardless of whether they had previous experience in commercial work or not; although, as we would expect, those who had the advantage of this experience were more likely to be confident of their ability to go into commercial work again. Furthermore, the very large majority (80 percent) of those engineers who have actually made the transfer from defense work to commercial work in the past reported that this transfer was "pretty easy" or " extremely easy" for them.

Managers' and Engineers' Responses Compared

We would not always expect the responses of managers to correspond with those of nonmanagerial persons in the same survey, because differences in response patterns may actually reflect differences in the way that particular matters are viewed or experienced by the two groups. Conversely, however, if the general direction of responses of managers and nonmanagerial persons is similar on particular items, then we have further assurance that honest and meaningful expressions of general attitudes or experiences are reflected in the questionnaire data. In other words, the responses of two different groups of observers of the same phenomena can be said to corroborate each other.

This appears to be the case for the general conclusion that "a more careful consideration of cost factors" is the most extensive problem for engineers transferring from defense to commercial work. The 69 managers in this study who filled out questionnaires (as well as being interviewed) are somewhat more likely than the total sample of engineers to indicate that "a more careful consideration of cost factors" is "definitely a problem" in the transfer situation (49 and 33 percent, respectively). Nevertheless, the general direction of the findings for both managerial and nonmanagerial groups was similar: both groups are more likely to indicate that the factor of cost considerations is definitely a problem than was true of any other factor included in the questionnaire. And when asked the additional question on what is "the most serious problem in the large scale transfer of engineers from defense to commercial work," the largest proportions of both managers and of engineers agreed that it is emphasis upon cost factors (46 and 36 percent, respectively).

Because of the nature of the item, the agreement between managers and engineers on the extent to which managers' attitudes would be a problem in the transfer situation is perhaps even more striking. Nineteen percent of the engineering managers and 14 percent of the total sample of engineers agreed that the assertion that "many commercial managers might believe that defense engineers are not well suited to commercial work" would be "definitely a problem." Another 42 percent of the managers and 22 percent of the engineers felt that this would "quite likely be a problem." Except for the matter of cost considerations, mentioned previously, no other item in the questionnaire received as much mention among managers or engineers as a problem in the transfer situation. Then, in answer to the question requiring respondents to indicate the most serious from among several possible problems in transfer, the proportions of managers and engineers who indicated that "managers' beliefs that defense engineers are not well suited to commercial work" were 23 and 19 percent, respectively. To repeat: these proportions for both groups were second in size to the proportions who had identified "a more careful consideration of cost factors" in commercial work as being the prime problem.

Nevertheless, the engineering managers in defense work also tend to agree with the total of all engineers in defense work that their own ability to transfer to commercial work would be high. Eighty-one percent of the defense managers and 65 percent of all the defense engineers say that it would be "pretty easy" or "extremely easy" for them to transfer into commercial work.

As would be expected, engineering managers are even more likely to identify themselves primarily with their employing organization in comparison to their engineering profession, than is the case among nonmanagerial engineers (77 percent to 58 percent). Managers are also slightly less likely to report that they are closely supervised in their jobs than is the case among nonmanagerial engineers. Six percent of the managers and ten percent of the engineers report that their immediate managers "closely directs my work," while the large majority of managers (87 percent) and of engineers (76 percent) say that their immediate supervisors "occasionally consult" on the respondent's work. Perhaps in part because of their greater extent of company identification and their direction of their own work, a larger proportion of managers (72 percent) than of engineers (54 percent) report that they are "satisfied" or "very satisfied" with their work situations in general.

In sum, it appears that in questions on attitudes or opinions regarding the transfer situation, the responses from managers and from engineers were consistent, at least in group tendencies. There are some differences in group responses to attitude or experience items that are not the main foci of this study, but the response differences that did show up are in a direction that would be expected and thus lend general support to the validity of the data derived from the questionnaire.

Engineers' and Scientists' Responses Compared

Several questions contained in the questionnaire for this study of engineers were also included, with the same wording, in a previous nationwide questionnaire survey of scientists (physicists, chemists, mathematicians, and biologists).* Although we would again expect scientists to differ from engineers in the way they answer certain questions, it is nevertheless possible to examine some data from this previous survey to test further the generalizations in the present study about (1) differences between managerial and nonmanagerial perspectives and (2) differences between commercial and defense work situations.

Thus, for example, science managers (professional scientists in managerial capacities in industrial firms) are like engineering managers, in that they are more likely to be generally satisfied in their jobs than are nonmanagerial scientists or engineers in industry, as may be seen in the following tabulation:

	Proportion "Satisfied" or "Very Satisfied" with Job in General
Science managers in industry (N = 517)	66%
Scientists in industry (N = 1,030)	57
Engineering managers	72
Engineers	54

Science managers in industry are also like their engineering management counterparts in the fact that they are more likely to identify themselves with their employing organizations rather than their professions:

---

* For a description of preliminary findings from this study and a discussion of the survey methodology, see H. M. Vollmer, Work Activities and Attitudes of Scientists and Research Managers: Data from a National Survey, "R&D Study Series," Menlo Park, California, Stanford Research Institute, 1965.

	Proportion Identifying Self Primarily with:	
	Employing Organization	Profession
Science managers in industry	58%	41%
Scientists in industry	40	59
Engineering managers	77	23
Engineers	58	42

At the same time, scientists and science managers are more likely to be professionally oriented in their self-identifications than are their counterpart engineers and engineering managers, as would be expected from all the studies of differences in the orientation of scientists compared with engineers.*

Looking at data only for nonmanagerial scientists and engineers, we can see further support for some of the generalizations about similarities or differences among the defense and commercial work environments. Scientists in aerospace and in atomic energy activities can be considered to be mostly in defense-related industrial activities, and scientists in petrochemical and in food and drugs activities to be in two different kinds of commercially-oriented industrial activities.

In making these kinds of comparisons, we can see, for example, that scientists in defense-related activities, like defense engineers, are more likely to be primarily oriented toward their professions than is the case among their counterparts in commercial industries:

	Proportion Identifying Self Primarily with:	
	Employing Organization	Profession
Defense scientists†		
Aerospace industry (N = 127)	32%	69%
Atomic energy industry (N = 58)	22	78

---

* See, for example, C. R. Shepherd, "Orientations of Scientists and Engineers," Pacific Sociological Review, Vol. 4, 1961, pp. 79-83.

† H. M. Vollmer, Work Activities..., op. cit., p. 84.

	Proportion Identifying Self Primarily with: Employing Organization	Profession
Commercial scientists*		
Petrochemical industry (N = 250)	48%	51%
Food and drugs industry (N = 149)	39	60
Defense engineers	55	45
Commercial engineers	64	36

Also, scientists in defense activities are similar to engineers in these same activities in that they are slightly more likely to have more freedom from close supervision than is the case among their counterparts in commercial industries. Nevertheless, the large majority in both defense work and commercial work report an intermediate or moderate amount of direction in their work:

	Proportion Reporting: Close Direction	Occasional Consultation	Rare Consultation
Defense scientists†			
Aerospace industry	9%	61%	29%
Atomic energy industry	5	69	26
Commercial scientists†			
Petrochemical industry	9	74	16
Food and drugs industry	9	76	15
Defense engineers	8	75	17
Commercial engineers	12	78	10

With regard to job satisfaction in general, it is noticeable that scientists are much more likely to be dissatisfied in industrial employment than in universities. In college, scientists are oriented in their undergraduate training and even more in their graduate work toward doing the kind of research that professors do in university environments. Many scientists ultimately end up in university employment, and are well satisfied with it. Some others go into research positions in nonprofit research laboratories or government research laboratories, and are almost as likely to be satisfied in these environments as they are in universities. In contrast, those who go into industrial employment are likely to experience the well-documented conflict between organizational requirements and scientific orientations.* But this conflict for scientists in industry may be no more severe than for many engineers in industry. The pattern of data for general job satisfaction among scientists in industry and among engineers in industry is similar, as may be seen in the following tabulation:

---

* H. M. Vollmer, Work Activities..., op. cit., p. 84.

† Ibid., p. 82.

	With Regard to Present Work Situation in General, Proportion Reporting		
	Satisfied or Very Satisfied	Somewhat Satisfied & Somewhat Dissatisfied	Dissatisfied or Very Dissatisfied
Scientists in universities† (N = 1,942)	71%	25%	4%
Scientists in nonprofit research organizations† (N = 273)	71	25	4
Scientists in federal government laboratories† (N = 382)	65	31	3
Scientists in industry† (N = 1,030)	57	35	7
Defense scientists			
Aerospace industry	44	41	15
Atomic energy industry	65	31	3
Commercial scientists			
Petrochemical industry	55	36	8
Food and drugs industry	59	35	7
Defense engineers	53	39	7
Commercial engineers	55	38	7

---

* See, for example, W. Kornhauser, Scientists in Industry: Conflict and Accommodation, University of California Press, 1962.

† H. M. Vollmer, Work Activities..., op. cit., p. 84

At the same time, we can see in the above tabulation that there is no marked or consistent trend toward greater satisfaction or dissatisfaction among either scientists or engineers in defense work compared with those in commercial work. Scientists in aerospace companies are more likely to be dissatisfied in their work, perhaps because of the particularly hectic conditions of large scale program and project work that prevail in that particular industry--conditions that contrast markedly with the kinds of looser project schedules that prevail in more academic contexts. Scientists in the aerospace industry are also the least likely to feel that management has given their work "the recognition it deserves."* In contrast, scientists in other sectors of defense-related activities, such as atomic energy research and development, are much more likely to find a reasonably comfortable accommodation to the conditions of work--even more satisfactory than they may find in certain sectors of commercial industry.† And, as pointed out previously, defense engineers seem to be almost as likely to be satisfied with their jobs as are engineers in commercial work, even though a sizable proportion of defense engineers may want to get out of the uncertainties of the defense business in the long run. In any case, there are no data to indicate that defense work, per se, is a cause of any greater satisfaction or dissatisfaction among either engineers or scientists.

Conclusion

From comparisons of engineers' responses on different questions relating to the same matters, of engineers' responses compared with those of engineering managers, and of engineers' responses compared with those of scientists, we can conclude that support has been provided for the validity of the following general statements:

1. A more careful consideration of cost factors required in commercial engineering, and management attitudes of resistance toward the adaptability of defense engineers to commercial engineering work requirements, are the two most extensive problems connected with the large scale transferability of defense engineers.

---

* Ibid., p. 84.

† The findings with regard to management recognition of scientists' work are consistent with this conclusion.

2. Nevertheless, these problems can be overcome fairly easily by the majority of defense engineers.

3. There are no marked differences between defense and commercial engineers in such matters as closeness of supervision, recognition of work by management, or general job satisfaction.

4. However, engineers in defense work are somewhat less likely to identify with their employing organizations for a career than is the case among engineers in commercial work, and a fairly large proportion of defense engineers hope to make the transfer into commercial engineering in the future.

CITED REFERENCES

1. Reemployment Experiences of Martin Company Workers Released at Denver, Colorado, 1963-1964; Effects of Defense Employment Readjustments, Report submitted by the Martin Company, U.S. Arms Control and Disarmament Agency Publication 36, U.S. Government Printing Office, Washington, D.C., December 1966

2. The Dyna-Soar Contract Cancellation, Report submitted to the Department of Defense by the Washington State Employment Security Department under contract financed by the Department of Defense and ACDA, U.S. Arms Control and Disarmament Publication 29, U.S. Government Printing Office, Washington, D.C., July 1965

3. Mooney, Joseph Daniel, Displaced Engineers and Scientists: An Analysis of the Labor Market Adjustment of Professional Personnel, Ph.D. Dissertation, Massachusetts Institute of Technology, 1965

4. Shapero, Albert, Richard P. Howell, and James R. Tombaugh, An Exploratory Study of the Structure and Dynamics of the R&D Industry, Stanford Research Institute, Menlo Park, California, 1964

5. __________, The Structure and Dynamics of the Defense R&D Industry: The Los Angeles and Boston Complexes, Stanford Research Institute, Menlo Park, California, 1965

6. The Post-Layoff Labor Market Experiences of the Former Republic Aviation Corporation (Long Island) Workers, Report submitted by the New York State Department of Labor, U.S. Arms Control and Disarmament Agency Publication 35, U.S. Government Printing Office, Washington, D.C., August 1966

7. Weidenbaum, Murray L., and A. Bruce Rozet, Potential Industrial Adjustments to Shifts in Defense Spending: An Analysis of the Reduction in Strategic Programs, Prepared for the U.S. Department of Defense, Stanford Research Institute, Menlo Park, California, November 1963

8. Ginzberg, Eli, The Development of Human Resources, McGraw-Hill Book Co., Inc., New York, 1966

9. Reviews of Data on Science Sources, NSF 66-33, No. 10, December 1966

10. Shapero, Albert, and Howard M. Vollmer, Technical Profile of the Industry, The Industry-Government Aerospace Relationship, Stanford Research Institute, Menlo Park, California, 1964

11. Black, Ronald P., and Charles W. Foreman, Transferability of Research and Development Skills in the Aerospace Industry, Analytical Services Inc., Falls Church, Virginia, 1965

12. Rutzick, Max A., Worker Skills in Current Defence Employment, Monthly Labor Review, Vol. 90, No. 9, September 1967, pp. 17-20

BIBLIOGRAPHY

For items specifically mentioned in the text, see Cited References.

Creating Second Sources of Engineering Manpower, The Institute of Electrical and Electronics Engineers, Inc., New York, 1966

Defense Industry Diversification - An Analysis with Twelve Case Studies, Report submitted by Denver Research Institute, U.S. Arms Control and Disarmament Agency Publication 30, U.S. Government Printing Office, January 1966

Draheim, Kirk, Richard P. Howell, and Albert Shapero, The Development of a Potential Defense R&D Complex: A Study of Minneapolis-St. Paul, Stanford Research Institute, Menlo Park, California, 1966

Employment Service Statistics, Supplement to Employment Service Review, U.S. Department of Labor, January 1964

Engineer-in-Industry Committee, A Professional Look at the Engineer in Industry, National Society of Professional Engineers, Washington, D.C., 1955

Evaluation of Engineering Performance Committee, Evaluating Engineering Performance, National Society of Professional Engineers, Washington, D.C., October 1963

Exploring the Dimensions of the Manpower Revolution, U.S. Government Printing Office, Washington, D.C., Vol. 1, 1964

Haber, William, Louis A. Ferman, and James R. Hudson, The Impact of Technological Change: The American Experience, The W. E. Upjohn Institute for Employment Research, Michigan, February 1964

Hearings before the Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare, United States Senate, Part 1, U.S. Government Printing Office, Washington, D.C., May 1963

Hearings before the Subcommittee on Employment and Manpower of the Committee on Labor and Public Welfare, United States Senate, Part 2, U.S. Government Printing Office, Washington, D.C., June 1963

Holland, John L., The Psychology of Vocational Choice, Blaisdell Publishing Co., Waltham, Massachusetts, 1966

Horowitz, Morris A., Engineering and Scientific Manpower Problems: An Annotated Bibliography, For the American Society for Engineering Education, Bureau of Business and Economic Research, Boston, August 1957

The Implications of Reduced Defense Demand for the Electronics Industry, Report submitted by Battelle Memorial Institute, U.S. Arms Control and Disarmament Agency Publication 28, U.S. Government Printing Office, Washington, D.C., September 1965

Industrial Conversion Potential in the Shipbuilding Industry, Report submitted by Midwest Research Institute, U.S. Arms Control and Disarmament Agency Publication, U.S. Government Printing Office, Washington, D.C., March 1966

Kornhauser, W. Scientists in Industry: Conflict and Accomodation, University of California Press, Berkeley and Los Angeles, 1962

Kuhn, James W., Scientific and Managerial Manpower in Nuclear Industry, Columbia University Press, New York, 1966

Levitan, Sar A., Federal Manpower Policies and Programs to Combat Unemployment, The W. E. Upjohn Institute for Employment Research, Michigan, February 1964

__________, Reducing Worktime as a Means to Combat Unemployment, The W. E. Upjohn Institute for Employment Research, September 1964

__________, Vocational Educational and Federal Policy, The W. E. Upjohn Institute for Employment Research, Michigan, May 1963

The Long-Range Demand for Scientific and Technical Personnel: A Methodological Study, Prepared for the National Science Foundation - NSF 61-65, U.S. Department of Labor, Washington, D.C.

Loomba, R. P., et al., Proceedings of the National Symposium on Stabilization of Engineering and Scientific Employment in Industry, San Jose, November 1966

Loomba, R. P., A Study of the Re-employment and Unemployment Experiences of Scientists and Engineers Laid Off from 62 Aerospace and Electronics Firms in the San Francisco Bay Area During 1963-65, Prepared for the U.S. Department of Labor, February 1967

Mackin, Paul J., Extended Unemployment Benefits, The W. E. Upjohn Institute for Employment Research, Michigan, April 1965

Major BLS Programs: A Summary of their Characteristics, 1963 Edition, U.S. Department of Labor, Washington, D.C., August 1962

Manpower Research and Training: Report of the Secretary of Labor, U.S. Department of Labor, Washington, D.C., March 1964

National Defense and Southern California 1961-70, Southern California CED Associates, California, December 1961

Occupational Mobility Through MDTA Training, U.S. Department of Labor, Manpower Evaluation Report Number 2, Washington, D.C., March 1964

Occupational Outlook Handbook, 1966-67 Edition, U.S. Government Printing Office, Bulletin No. 1450, Washington, D.C., 1966

The Professional Engineers Conference Board for Industry, Engineering Professionalism in Industry, Opinion Research Corp., New Jersey, 1960

Renewable Resources, National Academy of Sciences - National Research Council, Publication 1000-A, Washington, D.C., December 1962

Retraining and Labor Market Adjustment in Western Europe, U.S. Government Printing Office, Washington, D.C., August 1965

Scientific and Technical Personnel in Industry, 1961, U.S. Department of Labor for the National Science Foundation - NSF 63-32, Washington, D.C.

Shepherd, C. R., Orientations of Scientists and Engineers, Pacific Sociological Review, Vol. 4, 1961, pp. 79-83

Smith, Harold T., Education and Training for the World of Work: A Vocational Program for the State of Michigan, The W. E. Upjohn Institute for Employment Research, Michigan, July 1963

Social and Economic Aspects of Natural Resources, National Academy of Sciences - National Research Council, Publication 1000-G, Washington, D.C., December 1962

Survey of Attitudes of Scientists and Engineers in Government and Industry, U.S. Government Printing Office, Washington, D.C., April 1957

Technological Advances and Skilled Manpower, Implications for Trade and Industrial Education: An Annotated Bibliography, U.S. Government Printing Office, Washington, D.C., November 1956

Toward Full Employment: Proposals for a Comprehensive Employment and Manpower Policy in the United States, U.S. Government Printing Office, Washington, D.C., April 1964

Vollmer, H. M., Work Activities and Attitudes of Scientists and Research Managers: Data from a National Survey, Stanford Research Institute, R&D Study Series, Menlo Park, California, 1965

__________, The Uses of Questionnaire Surveys in the Analysis of Individual and Group Factors in Research Organizations, in Twentieth National Conference on the administration of Research, Denver Research Institute, Denver, 1967, pp. 7-14

Weidenbaum, M. L., Industrial Impact of Disarmament, The American Journal of Economics and Sociology, Vol. 22, No. 4, October 1963

ERIC Clearinghouse
AUG 14 1969
on Adult Education

★ U.S. GOVERNMENT PRINTING OFFICE : 1968 O—305-215 (96)